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The Ottawa Field-Naturalists' Club

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Governor General of Canada

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COVER: Adult Le Conte's Sparrow, *Ammospiza leconteii*, attending to the nest. 21 July 1999. Photo by Michael Patrikeev. See article New nesting records of the Le Conte's Sparrow – pages 22-26.

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Predicting Bird Oiling Events at Oil Sands Tailings Ponds and Assessing the Importance of Alternate Waterbodies for Waterfowl: a Preliminary Assessment

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Ronconi, Robert A. 2006. Predicting bird oiling events at oil sands tailings ponds and assessing the importance of alternate waterbodies for waterfowl: a preliminary assessment. Canadian Field-Naturalist 120(1): 1-9.

Tailings ponds are an integral part of oil sands mining development in northeastern Alberta, but waterfowl and shorebirds often land in these ponds during spring migration where they may become covered with oil. For decades, managers have developed and implemented methods for deterring birds from landing in these ponds, yet no deterrent strategy is fully effective. Therefore, to enhance deterrence strategies, it will be important to understand the environmental conditions that influence bird use of tailings ponds. This study quantified waterfowl flights over, and use of, tailings ponds and compared this use to waterfowl activity at natural waterbodies in the region over a single spring migration period. Results suggest that waterfowl are most likely to land on tailings ponds before lakes have thawed, after which migratory ducks appeared mainly to use natural waterbodies for migratory stopover sites. Very high numbers of waterfowl were observed on one waterbody, Kearl Lake, suggesting that this lake may be of greater importance to spring staging waterfowl than previously thought. A small sample of birds oiled at tailings ponds were examined in relation to spring weather conditions. Logistic regression analysis demonstrated that the probability of birds being oiled tended to increase with precipitation levels. Results of this study suggest that (1) preservation of natural waterbodies may play an important role in minimizing bird use of tailings ponds, and (2) future bird deterrence efforts should especially aim to deter birds during rainy weather conditions when birds may be more likely to become oiled. These results were from a small sample size, are preliminary in nature, and should be interpreted with caution. A concerted and careful effort to collect and thoroughly analyze long-term records of oiled birds may reveal important environmental effects predicting bird oiling events.

Key Words: waterfowl, oil sands, mining, tailings ponds, lakes, weather, migration, radar, conservation, Alberta.

In northeastern Alberta, oil sands development has grown considerably over the past several decades. This industry promises to grow into the 21st century since recent oil reserve estimates have placed Canada second on the world list of oil reserves with 175 billion barrels of oil in oil sands deposits (CAPP 2003*). Although most of these reserves are extractable with new drilling technologies, an estimated 20% are recoverable only with open pit mining practices (CAPP 2003*). One of the primary environmental concerns stemming from oil sands mining is the existence of tailings ponds which have oil floating on the surface. Birds landing on these ponds might become covered in oil and die. This problem has been recognized since the initial development of oil sands mining (SCL 1973; Schick and Ambrock 1974*; Ward et al. 1976*; Hennan and Munson 1979) and significant effort has been dedicated to researching the conditions that promote and prevent birds from becoming oiled (Boag and Lewin 1980; Gulley 1980; Yonge et al. 1981*; Ronconi and St. Clair 2006; also see review by Golder Associates 2000*). Nevertheless, birds still continue to be oiled and oil sands companies carry on their search for better means of reducing these incidents.

Previous oil sands research recommended the creation of uncontaminated waterbodies in close proximity to tailings ponds, allowing birds alternate landing sites (Gulley 1980; Golder Associates 2000*). Moreover, research in other industrial contexts indicates that birds can be deterred from an area more effectively when alternate roosting sites (including ponds) are available (Martin and Martin 1984; Gosler et al. 1995; Stevens et al. 2000). Yet others have argued that such diversionary ponds would only draw more birds to the region (Allen 1990). Instead, the preservation of naturally occurring waterbodies may be an optimal solution to provide alternate landing sites for birds, particularly if these alternative bodies are already used by migrating birds in the region. Comprehensive surveys of waterfowl at the major waterbodies in the vicinity of Alber-

ta's oil sands were conducted prior to oil sands development (Hennan and Munson 1979), but the current status of these waterbodies and their use by migratory birds are unknown. Moreover, subsequent surveys of waterbird numbers at natural waterbodies (Shortt 1985*; Van Meer and Arner 1985*) did not compare levels of bird activity between these natural ponds and nearby tailings ponds. Such information would make it possible to assess the importance of alternative waterbodies as stopover sites during migration, and to assess temporal changes within seasons in the attractiveness of tailings ponds to waterfowl.

In addition to information about the alternative stopover sites for migrating birds, researchers and managers have also sought to understand the conditions under which birds become oiled on tailings ponds. Over a three-year period, Gulley (1980) identified three main conditions as determinants of the numbers of birds that were killed each year. First, more birds were oiled when more birds were migrating (Gulley 1980), though the synchrony of migration is not fully predictable and tends to vary among both years and species (Bellrose 1976). Second, cold spring weather and delayed ice break-up correlated with bird oilings. Finally, greater than average seasonal rainfall has been correlated with higher rates of oiled birds. In contrast, other studies failed to observe any environmental (wind, temperature, precipitation) effects on the probability of bird landings in tailings ponds (Ronconi and St. Clair 2006). Yet neither analysis examined the frequency of bird oiling events in relation to daily weather patterns and this information may be most likely to reveal the causes of variation.

The study is situated at one of more than 10 oil sands tailings ponds operating in northeastern Alberta (Golder Associates 2000*), all of which are situated along a major migratory flyway for waterfowl traveling to the Peace-Athabasca Delta, an internationally significant staging area (Bellrose 1976; Hennan and Munson 1979). The objectives in this study were three-fold. First, I examined the seasonal abundance and direction of migratory bird movements over tailings ponds. Second, I compared numbers of waterfowl that landed at tailings ponds with numbers of birds at natural ponds in a broader region and with historical data. Finally, I assessed potential correlations between daily weather conditions and the frequency of oiled birds found during April and May of 2003. Because data were available only for a single season, I present these as preliminary results and encourage future researchers to investigate these findings over longer time periods.

Methods

The study was undertaken at the Muskeg River Mine (MRM), Albian Sands Energy Ltd., located approximately 75 km north of Fort McMurray, Alberta (Figure 1). During April and May 2003, the mine was beginning initial oil production stages. The tailings pond complex consists of three ponds totaling ~ 740 ha of surface area when full, but water coverage during this study period was approximately 530 ha. Natural waterbodies were selected for surveys based on accessibility, size, and proximity to the MRM tailings ponds. These included two lakes near the mine, four lakes south of the mine near other oil sands development, and eight lakes north of the mine that were isolated from development (Figure 1). As these lakes were situated along a North-South axis relative to the MRM, all lakes were potentially usable by waterfowl migrating along this corridor.

Airport radar systems have been used to study bird migration patterns in Alberta (Richardson and Gunn 1971), and marine radar has been used by ornithologists to study various aspects of bird activity (Cooper et al. 1991; Burger 1997; Bertram et al. 1999; Gauthreaux and Belser 2003). In this study, marine type radar was used to assess spring migratory activity over the MRM tailings ponds between 3 and 29 May 2003. Migratory activity was measured by the groups of birds flying over the study area (groups rather than individuals are identifiable by radar) and the direction of flight. Radar observations were made from 0.5 hours before sunrise to 4 hours after sunrise. This period was considered a high migratory period in northeastern Alberta (Richardson and Gunn 1971). Owing to some technical difficulties, directional data were not recorded for the first four days of this period, and data collection was not possible on six other days because of heavy precipitation that obscured radar observations.

Tailings pond and lake surveys were conducted from fixed observation points using binoculars and spotting scopes. Tailings ponds were surveyed regularly from 18 April to 29 May, and lakes were surveyed 9 to 28 May as most lakes were still completely or partially frozen during the first week of May. Observers counted individual ducks, gulls, coots, loons, and grebes on the water. No more than two or three geese were observed during any lake count; therefore, goose counts were omitted from the results. Because of the large size of McCleland Lake, all portions of it were not simultaneously visible, thus counts were only a minimum estimate of bird numbers on that lake. Kearl Lake was surveyed more often than the other natural waterbodies because it was nearest to the MRM tailings ponds and thus most likely to offer an alternate landing site for migratory birds. During the mid-1970s Mildred Lake was dammed, converting most of the lake into a tailings pond and leaving only a portion of the lake in its semi-natural state. Surveys of Mildred Lake included only the semi-natural portion. When applicable, results were compared to previous surveys (see Hennan and Munson 1979 for detailed waterfowl surveys in the region).

Reports of oiled birds on the tailings ponds were collected from 10 April to 29 May, inclusive. Although systematic searches for oiled birds were not conduct-

ed, observers spent 4 to 8 hours observing waterfowl at the tailings ponds on most days thus ensuring some consistency in effort throughout this period. Weather data for wind speed and direction, temperature, and rainfall were recorded from meteorological stations on site, and snowfall events were converted into rainfall equivalency. Mean temperature is reported here as the daily mean of maximum and minimum temperatures. Wave conditions on the ponds and percent cloud cover were recorded by observers. All occurrences of oiled birds are reported (below); however, analyses of weather effects were conducted only on oiled birds that were still alive when found, an assumption that those birds became oiled either the day they were found or the previous night. For analysis by logistic regression, oiled birds were the dependent variable (1 = days with oiled birds; 0 = days with no oiled birds). Days when observers were not present on site were excluded from analyses. Weather data were the independent variables (wind, temperature, precipitation, wave conditions, % cloud cover). Except for wave conditions, analyses of weather effects were assessed for three time periods: date of oiled bird finding, one day prior (i.e. previous 24 hour conditions), and two days prior (i.e. previous 24-48 hour conditions). Wave condition was only analyzed for the first two time periods since it was considered likely that rough water effects would not persist for as long as two days. Logistic regression analysis (SPSS 11.5) was used to assess weather effects and to build a model for predicting their effects on the probability of birds being oiled. Owing to small sample sizes of data from a single season, a liberal alpha value (0.10) was used for logistic regression analysis. Tests were conducted for inter-

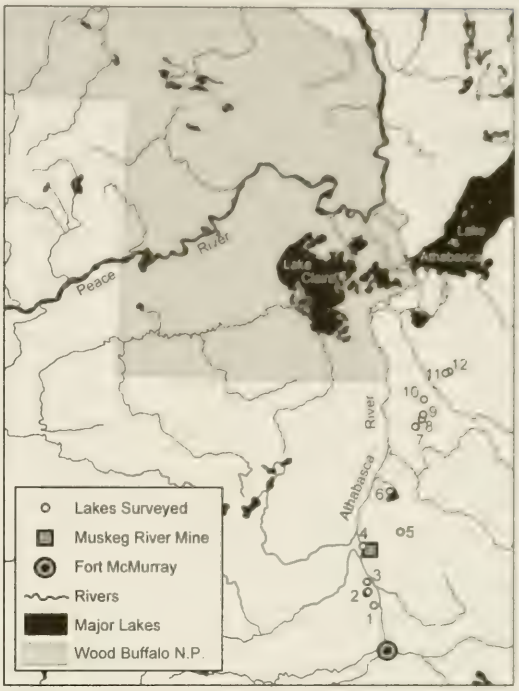

FIGURE 1. Map of study area showing the location of the Muskeg River Mine and surrounding natural waterbodies surveyed in 2003. Lake names are as follows: (1) Poplar, (2) Ruth and Crane, (3) Mildred, (4) Isadore's, (5) Kearl, (6) McCleland, (7) Unknown Lakes, (8) Go Go, (9) Herb, (10) Six Lakes, (11) Larocque, and (12) Net.

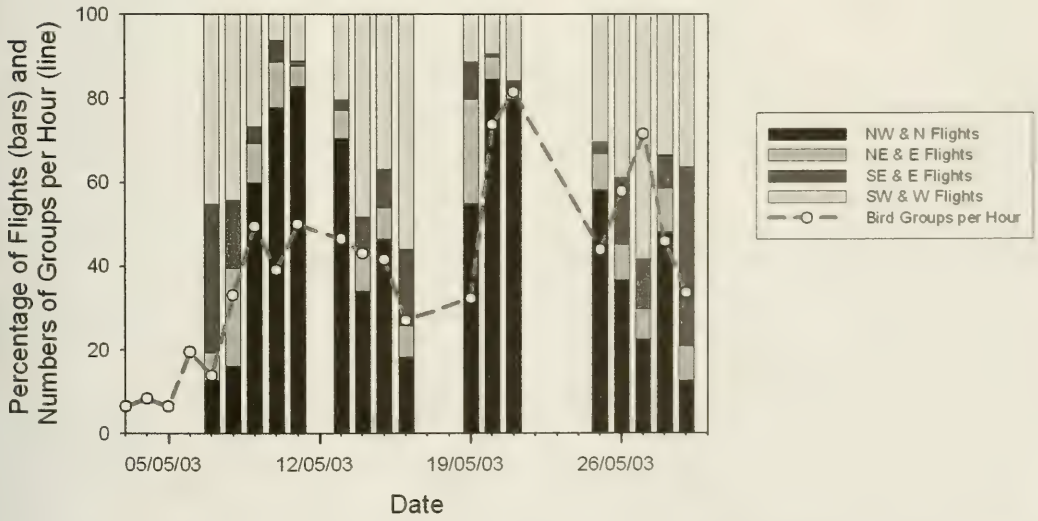

FIGURE 2. Migration patterns from radar data at the Muskeg River Mine tailings ponds, 3-29 May 2003. Bird groups were the unit of measure because group size could not be inferred from radar images. Gaps in the data set resulted from days of heavy precipitation which obscured radar observations.

TABLE 1. Numbers of waterfowl at the Muskeg River Mine (MRM) and surrounding natural waterbodies, 2003.

Location	Date	Coordinates	Distance (km) Lake from MRM	Size[1]	Gulls	Ducks	[2]Other Water birds
Muskeg River Mine							
Tailings Ponds	18 April	57°13'47"N, 111°35'10"W	0		0	35	3
	20 April				0	8	0
	23 April				0	32	0
	24 April				0	13	0
	25 April				4	13	0
	26 April				0	22	4
	27 April				5	55	0
	03 April				0	86	0
	04 April				0	90	0
	05 April				0	16	0
	06 May				0	166	58
	07-29 May				0-14	≤ 28	≤ 2
Near Muskeg River Mine							
Kearl Lake	09 May	57°18'08"N, 111°15'06"W	19	>	15	104	11
	15 May				300	2700	present
	19 May				440	859	9
	30 May				2	8	9
Isadore's Lake	26 May	57°13'43"N, 111°36'29"W	1	=	66	102	2
North of Muskeg River Mine							
McCleland Lake[3]	23 May	57°30'35"N, 111°21'16"W	32	>>	12	645	5
Unknown Lake	23 May	57°50'25"N, 111°06'29"W	72	<	4	0	0
Unknown Lake 2	23 May	57°50'28"N, 111°06'46"W	72	<	0	4	2
Go Go Lake	23 May	57°52'48"N, 111°02'56"W	77	<	0	0	2
Herb Lake	23 May	57°54'13"N, 111°02'11"W	80	=	0	5	1
Six Lakes	24 May	57°58'50"N, 111°01'45"W	88	=	0	0	3
Net Lake	24 May	58°07'23"N, 110°46'55"W	108	=	0	5	3
Larocque Lake	24 May	58°06'51"N, 110°49'11"W	107	=	3	0	1
South of Muskeg River Mine							
Mildred Lake	25 May	57°02'45"N, 111°33'52"W	18	=	0	0	0
Crane Lake	25 May	56°59'45"N, 111°33'12"W	24	<	0	158	present
	28 May				0	106	5
Ruth Lake	25 May	56°59'22"N, 111°34'06"W	25	>	19	306	present
	27 May				12	350	12
Poplar Reservoir	27 May	56°55'32"N, 111°29'50"W	32	=	0	15	2

[1] Relative to Muskeg River Mine tailings ponds = (approximately equal), > (larger), < (smaller).
[2] Includes coots, loons, grebes.
[3] Entire lake was not observable, therefore counts are minimum numbers of birds.

actions and confounding variables. For detailed description of the model-building approach see Ronconi and St. Clair (2006) and Hosmer and Lemeshow (1989).

Results

Counts of bird groups by radar provided an indication of overall bird activity relative to the numbers of birds landing at tailings ponds. The radar system was operational from 3 – 29 May, during which two peaks in migratory activity were observed (Figure 2). Peaks in migratory flights (NW & N flights) coincided with two peaks in bird activity (bird groups per hour). However, a third peak in groups per hour on 27 May showed no corresponding peak in NW & N flights. Notwithstanding the three peaks, these data document high migratory volumes over most of May when counts of waterfowl on lakes were conducted. However, the numbers of ducks that also landed on the tailings ponds (Table 1) were consistently low over this same period with no comparable peaks.

Counts of birds at tailings ponds and natural waterbodies showed much variability and peaks occurred at different times for different lakes. Counts of ducks and other waterbirds at the MRM tailings ponds (Table 1) showed peaks in activity from 26 April through to 6 May, after which activity dropped considerably and remained low throughout May. Conversely, high counts of birds on surrounding lakes were observed in May (Table 1), though comparable counts from April were not possible because the natural waterbodies were still frozen at that time. In particular, Kearl Lake showed a peak around mid May with an estimated 2700 ducks

and 300 gulls on 15 May. As numbers were low at Kearl Lake in early May, these data, in combination with low May counts at tailings ponds, suggest that bird use of tailings ponds may have shifted to natural waterbodies for much of May. North of MRM, counts showed very low numbers except for McCleland Lake with over 600 ducks on 23 May. This high count suggests that McCleland was still being used as a migratory stopover at this time, but lakes farther north were likely only occupied by small numbers of breeding pairs. Between 25 and 27 May, counts of lakes south of MRM had higher numbers than maximum counts at MRM tailings ponds throughout April or May, but by this date many of these birds may have been resident breeders.

Although duck use of tailings ponds appeared low in comparison with natural waterbodies, overall duck numbers for this region were higher than historical surveys reported. Comparisons with Hennan and Munson's (1979) surveys showed several changes (Table 2). Duck numbers at McCleland Lake fell within the range of historical counts and were higher than four of the five years surveyed between 1973-1977, even though McCleland was only censused once in 2003. The highest count at Kearl Lake in 2003 was 4.6 times the maximum recorded by once annual surveys between 1973 and 1977. South of the MRM, Mildred Lake showed no use in 2003, in contrast to abundant use in previous surveys, whereas numbers were higher at Ruth Lake than were recorded during the 1970s. Due to inconsistencies in data collection methods and dates of surveys, we can not speculate on trends or changes in waterfowl abundance since the 1970s. However the dramatically high count of ducks on Kearl Lake suggest that this lake may be more heavily used as a migratory stopover site than might have been suspected from earlier surveys.

Fifteen oiled birds were observed at the MRM tailings ponds during the study period (Table 3), nine of which were alive when found. Of these, four Lesser Scaup (*Aythya affinis*) were lightly oiled and able to fly, making it probable that these were non-fatal oiling events. The remaining live oiled birds included one goose, one shorebird, one gull and two ducks. Days when live oiled birds were found were plotted in relation to weather variables (Figure 3). A logistic regression analysis was conducted on 47 days of observations, six of which had reported live oiled birds. This analysis found no effect of temperature, sea-state, wind direction, or cloud cover. Univariate analyses found date ($P = 0.160$) to be marginally significant, and rainfall ($P = 0.086$), rainfall during the previous 24 hours ($P = 0.066$), and wind speed during the previous two days ($P = 0.050$) as significant variables affecting the probability of birds being oiled. However, when combined in a multivariate analysis no variables retained significance but the two rainfall variables were only

TABLE 2. Comparisons of spring 2003 duck counts with historical counts from 1973-1977 (Hennan and Munson 1979).

	Maximum Number of Ducks Recorded During Spring Migration					
Location	1973	1974	1975	1976	1977	2003
MRM Tailings Ponds	–	–	–	–	–	166
Kearl Lake	529	586	24	37	140	2700
McCleland Lake[1]	194	1154	225	360	195	645
Mildred Lake[2]	246	313	136	17	–	0
Ruth Lake	113	20	26	11	–	350
Poplar Reservoir	–	–	16	1	14	15

[1] For 2003 surveys the entire lake was not observable; therefore, count is a minimum estimate of ducks

[2] ca. 1975 most of Mildred Lake was converted into a tailings pond. Surveys in 2003 checked only the portion of Mildred Lake that remains in its natural state.

TABLE 3. Summary of oiled birds found at the Muskeg River Mine tailings ponds, April and May 2003.

Date	Common Name	Scientific Name	Group Size	Status	Oiled Status
26 April	goose spp.	unknown	1	Live	heavy – >80%
03 May	Common Goldeneye	*Bucephala clangula*	1	Live	heavy – 80%
19 May	Lesser Scaup	*Aythya affinis*	4	Live	light < 10%[1]
20 May	Bonaparte's Gull	*Larus philadelphia*	1	Live	heavy – 70%
21 May	small shorebird	*Calidris* spp.	1	Live	heavy – 60%
21 May	Lesser Yellowlegs	*Tringa flavipes*	1	Dead	moderate – 30%
26 May	Northern Shoveler	*Anas clypeata*	1	Live	heavy > 50%
26 May	Northern Shoveler	*Anas clypeata*	1	Dead	heavy – 100%
26 May	small Shorebird	unknown	1	Dead	heavy – 100%
26 May	medium passerine	unknown	1	Dead	heavy – 90%
26 May	large shorebird	unknown	1	Dead	heavy – 100%

[1] Lightly oiled but able to fly.

marginally non-significant ($P = 0.107$ and 0.105). To examine the apparent, though non-significant, effect of rainfall on birds being oiled, the cumulative rainfall was summed for the day of plus day before oiled birds were found and this had a significant effect (*Wald* = 4.973, d.f. = 1, $P = 0.026$) on the probability of birds being oiled. The positive coefficient of this variable indicated that the probability of a bird becoming oiled increased with higher rainfall. With the cumulative rainfall variable, the model was significant (*-2LL* = 30.264, *model* $\chi^2 = 5.636$, d.f. = 1, $P = 0.018$), but the model fit was weak (*Nagelkerke's* $r^2 = 0.212$, *Hosmer and Lemeshow test* $\chi^2 = 1.330$, d.f. = 1, $P = 0.095$). Small sample size likely contributed to the marginal significance of variables and the poor fit of the model, yet the persistence of rainfall effects indicate that precipitation was related to birds being oiled this year and this may be true more generally.

Discussion

Timing of Spring Migration

Although the radar system was not operational in April, visual observations suggested that migration activity in the study area was fairly low in April and early May and that migration peaked in mid-May. The radar was also not in operation (due to weather) for six days in May near peak migration (Figure 2); therefore, migration records presented here may have missed some critical portions of the migration. Nevertheless, the results on migration timing agree with other studies in northeastern Alberta. Richardson (1969) reported peak spring migration over east-central Alberta in May. Aerial surveys of lakes in this region during 1972 and 1973 reported peak numbers on 15 May and 25 May, respectively (SCL 1973). Likewise, Schick and Ambrock (1974*) showed peak migration to occur in middle and end of May in 1973. During aerial surveys in 1976/1977, Hennan and Munson (1979) reported peak spring migration for ducks in early May, with most abundant species being scaup (*Aythya* sp.), Ring-necked Ducks (*Aythya collaris*), Buffleheads (*Bucephala albeola*), and to a lesser extent Mallards (*Anas platyrhynchos*). Annual variation in timing of spring migration is likely to vary with timing of ice break-up of the Athabasca River and also the Peace-Athabasca Delta (Schick and Ambrock 1974*).

Although the timing of migration in northeastern Alberta is relatively well known, the composition and numbers of birds passing through the area are less well known. During the same time period of this study in 2003, Ronconi and St. Clair (2006) reported the following numbers of birds flying over the tailings ponds: 1140 ducks, 2132 shorebirds, 11 339 geese, 218 swans, 965 gulls, 56 terns and 205 others (loons, grebes, cranes, herons, cormorants, coots). These numbers give some indication of guild composition during migration but should be used cautiously as such because these were visual, daytime observations and many birds in Alberta migrate at night and at high altitudes (Richardson 1971; Blokpoel 1973; Blokpoel and Burton 1973). Hennan (1972) reported hundreds of thousands of waterfowl using the Peace-Athabasca Delta as a spring staging area, thus providing some indication of the volume of birds that may pass over the tar sands area each year. Nevertheless, many individuals of some waterfowl species may also take alternate migration routes to Alaska or nest in southern Canada (Miller et al. 2005).

Finally, in this study area we may also be observing resident as well as migratory waterfowl. This study makes no distinction between the two groups; however, the high proportions of northwesterly and northerly flights (Figure 2) suggest that most of the birds observed were migrants. It is likely that the small numbers of birds observed on the tailings ponds in May and on some lakes in late May were residents rather than stopover migrants. Surprisingly, the ecology of waterfowl at staging and stopover areas is fairly poorly understood (Arzel et al. 2006).

Numbers of Birds on Ponds and Lakes

Despite the apparent peak in migration around mid-May, the numbers of ducks on the tailings ponds peaked sooner than this. Working in a nearby area, Gulley (1980) found that duck dependence on tailings ponds was higher when spring ice break-up was delayed. In 2003, ice break-up on the nearby Athabasca River began 23 April and was finished by 1 May, yet many of the nearby lakes remained at least partially frozen through the first week of May. Duck surveys at Kearl Lake showed low numbers on 9 May when this lake was still partially frozen, but numbers grew by 23 times only one week later when the lake was ice-free. These results are mainly qualitative, but they support the hypothesis of others (Gulley 1980; D. Martindale, personal communication) that duck use of tailings ponds is highly dependent on the availability of open water elsewhere. After 9 May, duck numbers at the MRM tailings ponds were seldom above 10 individuals, while thousands of individuals were using Kearl Lake less than 20 km away. Nevertheless, these conclusions about seasonal change in dependence on tailings (early spring) to natural waterbodies (mid to late May) are tenuous due to several inconsistencies in survey methodology: (1) Kearl Lake was the only natural water body surveyed more than twice, (2) most natural waterbodies were surveyed only in late May and might have missed peak migration, and (3) lack of personnel did not allow for simultaneous surveys of tailings ponds and natural waterbodies. Bird movements between wetlands may have been a concern; however, the extremely low numbers of ducks at the tailings ponds after 7 May suggest little, if any, movement between artificial and natural ponds after this date. Finally, no data are available on wetland characteristics, which were beyond the scope of this project but may have had significant influence on waterfowl use of waterbodies.

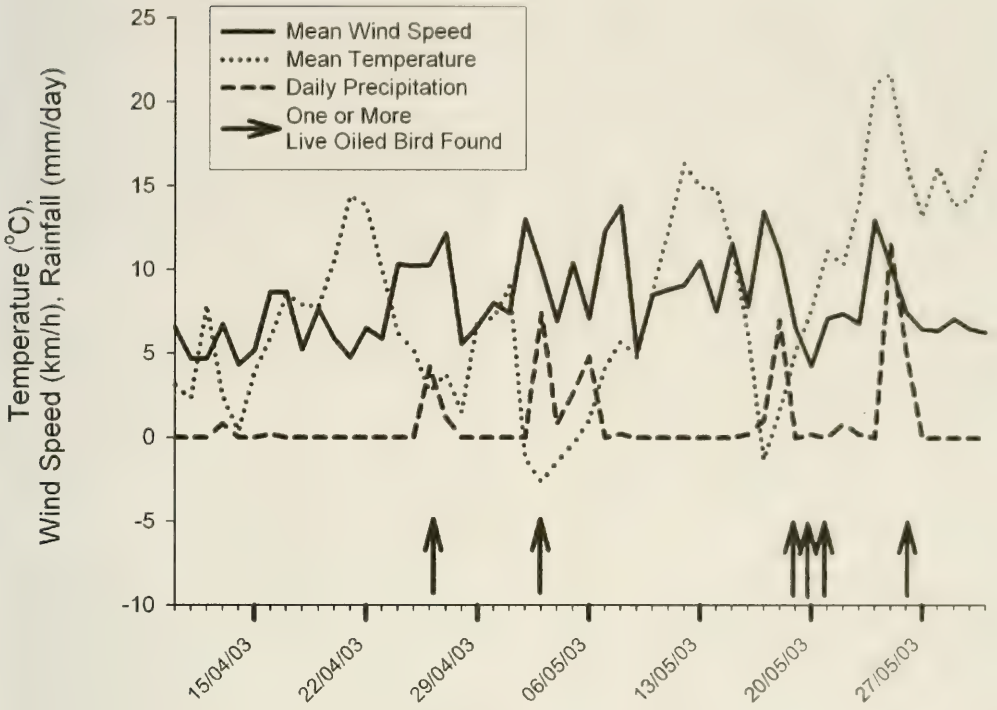

FIGURE 3. Weather patterns with respect to dates when live oiled birds were found at the Muskeg River Mine tailings ponds, April and May 2003.

Comparisons with census results from the 1970s suggest some changes in lake use. However, duck activity levels can vary widely within seasons, as was indicated in our results and other studies (e.g. SCL 1973; Gulley 1980; Van Meer and Arner 1985*; Shortt 1985*). The maximum counts between 1973 and 1977 were typically based on only one or two surveys during May, making them similarly prone to high variability. Although qualitative and tenuous, these comparisons reinforce the belief (SCL 1973; Schick and Ambrock 1974*; Ward et al. 1976*; Hennan and Munson 1979) that some lakes are important as stopover sites for migratory ducks, though not as major staging areas. As with our results, censuses from 1973 to 1977 ranked McCleland and Kearl lakes among the most important stopover sites for ducks (Hennan and Munson 1979). Other lakes in the region with high numbers included Little McCleland, Mildred, Horseshoe, and Saline lakes (Hennan and Munson 1979). The lack of ducks on Mildred Lake in 2003 is not surprising considering only a small portion of the lake remains in its natural state. The lack of ducks on remote lakes north of McCleland Lake was not surprising given the relatively small size of the lakes surveyed. Nonetheless, Hennan and Munson (1979) identified other remote lakes with high waterfowl densities, though these were not accessible for surveys by land in 2003.

Generally the oil sands region is not recognized as an important staging area for migratory waterfowl (SCL 1973; Schick and Ambrock 1974*; Ward et al. 1976*; Hennan and Munson 1979), although some staging does occur nearby. The Peace-Athabasca Delta, north of oil sands regions, has been recognized as an internationally significant staging area for hundreds of thousands of waterfowl (Hennan 1972). Further south of Fort McMurray, Gordon Lake was previously recognized as an important waterfowl staging area with spring numbers greater than 5600 in 1973 and 1974 (Hennan and Munson 1979). The count of 2700 waterfowl at Kearl Lake in 2003 suggest that this lake may bear greater importance as a staging area than might have been concluded from those earlier surveys, but further surveys may be needed to verify annual variation in waterfowl use of this lake. Surveys of other natural waterbodies also revealed that smaller ponds support small populations of birds throughout the spring and summer (Shortt 1985*). Because availability of natural waterbodies may minimize duck dependence on tailings ponds, further investigations of waterfowl use of these waterbodies is merited. Should it continue to appear that they are important to waterfowl, future oil sands developers may consider conserving these locations and avoiding the establishment of tailings ponds in close proximity to them.

Probability of Oiling

Logistic regression analysis of several weather variables found wind speed and precipitation to be the only variables that might predict the few observations of oiled birds in 2003. Strong winds may mix waters and spread oily films over wider areas, hence creating greater risk of oiling, but with consistent winds oily sheets may also be pushed to one shore of the pond. Thus any link between winds and oiling may be complicated. A two-day cumulative rainfall measure best predicted days with oiled birds, but rainfall the day of an oiling event and rainfall from the previous 24 hours showed some possible predictive ability. These uncertain results, along with small sample size, suggest only a potential effect of precipitation. Results of this study support a previous analysis across years (Gulley 1980) which showed that precipitation levels affected numbers of waterfowl deaths. Although Ronconi and St. Clair (2006) found no correlation between weather and bird landings on tailings ponds, the more important factor may be whether or not birds become oiled when they land.

If precipitation increases the frequency of birds being oiled, as these results cautiously suggest, I speculate that it may be caused by two possible mechanisms. First, poor weather conditions such as rain, strong winds, headwinds, and cold temperatures can delay migration, cause changes or a temporary reversal in migration direction, and cause migratory birds to be temporarily grounded (Richardson 1978; Elkins 1983). Waterfowl in particular appear to be erratic in their migratory behaviour which may be influenced by break-up of ice cover (Pöysä 1996), temperatures (Austin et al. 2002), weather fronts (Custer et al. 1997), and especially wind patterns (Bergman 1978; Liechti 1993; Bruderer 1994; Alerstam and Gudmundsson 1999). The significance of precipitation as a predictor of oiling may be due to correlations between rainfall and other weather changes, which may together be affecting bird movements and halting of migrations. The more frequently migratory waterfowl are forced to move and stop during migration, the greater the risk of encountering oil sands ponds and oil on the water surface in these ponds.

Second, precipitation may additionally increase oiling probabilities through birds experiencing reduced visibility during landings under rainy and snowy conditions. Without clear views of the water, they may be more likely to land in patches of oil which might otherwise be avoided. Reduced visibility as a causal mechanism may also explain the non-significance of wind speed, wind direction, and temperature since these variables should be less likely to affect the visibility of oil patches. Snow could affect in-flight visibility of birds, and on two of six days with oiled birds, the precipitation that occurred was a mix of rain and snow. Moreover, for three of the remaining days with oiling events (19, 20, and 21 May), heavy snow had fallen for two days previously (17 and 18 May). Although fog was not measured in this study, fog may also limit visibility and thus influence oiling events (Gulley 1980). Careful collection and thorough statistical analyses of long-term oiled bird records at tailings ponds may reveal important trends and weather association. These data could be valuable to improving the effectiveness of bird deterrent strategies, and I encourage oil sands companies to standardize collection protocols and pool their data for such an investigation.

Conclusions

As the development of oil sand mines continues in the 21st century, tailings pond and bird oiling problems will persist, and findings from current and previous studies will become more relevant to managers seeking a solution to this issue. Findings from this study suggest the importance of maintaining natural waterbodies in the region, especially those that are already used as migratory stopover sites for waterfowl. The significance of rainfall affecting numbers of birds being oiled suggests that bird deterrence efforts could benefit from enhancement on rainy days, and future deterrent development should pursue strategies that are effective during rainy weather more so than during clear conditions. With decades of data on oiled birds, and 30 years of research on bird deterrence, the oil sands industry in northern Alberta is positioned to offer significant insight into waterfowl management issues for future development here and at other sites of industrial development.

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A Test of Interspecific Effects of Introduced Eastern Grey Squirrels, *Sciurus carolinensis*, on Douglas's Squirrels, *Tamiasciurus douglasii*, in Vancouver, British Columbia

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Hwang, Yeen Ten, and Serge Larivière. 2006. A test of interspecific effects of introduced Eastern Grey Squirrels, *Sciurus carolinensis*, on Douglas's Squirrels, *Tamiasciurus douglasii*, in Vancouver, British Columbia. Canadian Field-Naturalist 120(1): 10-14.

We compared the effects of absence and presence introduced Eastern Grey Squirrels (*Sciurus carolinensis*) on the demography of native Douglas's Squirrels (*Tamiasciurus douglasii*) in two urban parks in Vancouver, British Columbia: Ecological Reserve #74 in Pacific Spirit Regional Park (Douglas's Squirrel only) and Stanley Park (Douglas's and Eastern Grey squirrels). Based on the exploitative competition hypothesis, we predicted that in the presence of introduced Eastern Grey squirrels, Douglas's Squirrels would occur at lower densities, have larger home ranges, lower body mass, and poorer reproduction. Using mark-recapture methods, we found no differences in density, home range, or body mass of Douglas's Squirrel between parks. However, the proportion of breeding Douglas's Squirrels was higher in Ecological Reserve #74 in the absence of Eastern Grey Squirrel, than in Stanley Park. We found no evidence that Eastern Grey Squirrels are displacing Douglas's Squirrels in Stanley Park, but less conspicuous negative effects such as reduced breeding propensity may still reflect the competitive interactions of the two squirrel species.

Key Words: Density, home range, body mass, reproduction, Eastern Grey Squirrel, *Sciurus carolinensis*, Douglas's Squirrel, *Tamiasciurus douglasii*, exploitative competition, British Columbia.

In western Canada, Eastern Grey Squirrels (*Sciurus carolinensis*) were introduced to Stanley Park in the city of Vancouver, British Columbia, shortly before 1914. The three to four pairs of introduced Eastern Grey Squirrels came from eastern Canada (Robinson and Cowan 1954). In the early 1980s, Eastern Grey Squirrels colonized the rest of the city of Vancouver, including many of its urban parks. Since then, Eastern Grey Squirrels have spread to many parts of the Greater Vancouver Regional District (Gonzales 1999, 2000).

On the mainland in southwest British Columbia, the native tree squirrel is the Douglas's Squirrel (*Tamiasciurus douglasii*); it is the ecological counterpart of the Red Squirrel (*T. hudsonicus*) that is widespread in temperate forests of North America (Steele 1998, 1999). The Eastern Grey Squirrel is native in eastern North America (Hall 1981) and its geographical range overlaps broadly with that of the Red Squirrel. Although Red Squirrels are associated with conifer forests and Eastern Grey Squirrels with mast-bearing hardwood forests, the two species often coexist in mixed forests or urban parks (Riege 1991). Forty years after Eastern Grey Squirrels were introduced to southwestern British Columbia, Robinson and Cowan (1954) conducted a live-trapping and observational study on Eastern Grey Squirrels in Stanley Park. They noted that, in deciduous habitat in Stanley Park, Eastern Grey Squirrels lived at high densities together with lower densities of Douglas's Squirrels. They suggested that the Eastern Grey Squirrels outcompete Douglas's Squirrels for food, and thus restrict Douglas's Squirrels to areas of predominately coniferous habitat (Robinson and Cowan 1954). Whether competitive interactions between the two species still exist today (> 80 years since the introduction of Eastern Grey Squirrels) remains unknown.

In Great Britain, Eastern Grey Squirrels were introduced at the end of the 19th century, and have caused the decline of the smaller native European Red Squirrel (*Sciurus vulgaris*) from its former range (Gurnell and Pepper 1993; Wauters and Gurnell 1999; Teangana et al. 2000). The mechanisms of replacement of European Red by Eastern Grey squirrels are not yet fully understood (Skelcher 1997). Juvenile recruitment of European Red Squirrels is typically lower when Eastern Grey Squirrels are present (Wauters et al. 2000, 2001). Also, diseases such as parapoxvirus have been hypothesized to facilitate the replacement of European Red Squirrels by Eastern Grey Squirrels in the United Kingdom (Tompkins et al. 2003).

The Eastern Grey Squirrel averages 400–700 g in body mass (Koprowski 1984), and is larger than Douglas's Squirrel, which averages 250-300 g (Steele 1999). Douglas's Squirrels feed primarily on coniferous seeds, new shoots of conifers, green vegetation, acorns, nuts, mushrooms, fruits, and berries. Also, Douglas's Squirrels actively defend food middens within their territory

(Steele 1999). In its native range, the Eastern Grey Squirrel feeds heavily on hickory nuts, beechnuts, acorns, and walnuts (Koprowski 1984); however, introduced Eastern Grey Squirrels in British Columbia feed extensively on maple, oak, hazelnut, mushrooms, berries and pine cones (Robinson and Cowan 1954). Both species prefer seeds, and other plant foods predominate in the diet only when seed crops are small (Moller 1983). Also, in Stanley Park, a few Eastern Grey Squirrels depend almost entirely on "hand-outs" from park visitors as an artificial food source. Eastern Grey Squirrels living in close proximity to humans often venture out of the forests and feed on artificial food sources.

Eastern Grey Squirrels have a dominance hierarchy and are not territorial (Flyger 1955; Thompson 1977) whereas Douglas's Squirrels are territorial year round (Steele 1999). Territorial behaviour exhibited by Douglas's Squirrels is mainly used against conspecifics similar to Red Squirrels (Smith 1981). Intruding Eastern Grey Squirrels are generally free to enter their territory (Robinson and Cowan 1954).

The interspecific effects of the introduced Eastern Grey Squirrels on the native Douglas's Squirrels are unknown in southwestern British Columbia. We tested the hypothesis that Eastern Grey Squirrels negatively impact native Douglas's Squirrels through exploitative competition for resources. With the introduction of Eastern Grey Squirrels, resources such as food and nest sites in areas where both squirrels occur would decrease, causing an increase in home range size of Douglas's Squirrels because larger ranges are needed to collect more food (Schoener 1971). Larger home ranges would decrease the density of Douglas's Squirrels in the given area. Also, with increased home ranges, Douglas's Squirrels would expend more energy foraging and defending the area and would have less energy for reproduction and maintenance. Therefore, we predicted that in areas with Eastern Grey Squirrels, Douglas's Squirrels would occur at lower densities, have larger home ranges and lower body mass, and that they would reproduce less well.

Materials and Methods

We worked at two study sites. The species co-occur in Stanley Park, which was the original site of Eastern Grey Squirrel introduction to western Canada, and of Robinson and Cowan's (1954) study. The control study site was Ecological Reserve #74 (Pacific Spirit Regional Park) where only Douglas's Squirrels occur. Although Eastern Grey Squirrels do not occur in Ecological Reserve #74, they do occur in residential areas nearby and are abundant on the University of British Columbia campus only 1-2 km distant.

Both study areas are in the Coastal Western Hemlock biogeoclimatic zone. The dominant coniferous species in Stanley Park were Western Hemlock (*Tsuga heterophylla*), Western Redcedar (*Thuja plicata*), and Douglas Fir (*Pseudotsuga menziesii*). Stanley Park is a mosaic of second- (> 50 years old) and old-growth (> 120 years old) conifer stands. Ecological Reserve #74 represented a mature conifer stand (> 90 years old) with Western Hemlock, Western Redcedar, Douglas Fir, and Sitka Spruce (*Picea sitchensis*) with scattered Red Alder (*Alnus rubus*) and Big Leaf Maple (*Acer macrophyllum*). Understory and ground cover in both study areas consisted mainly of Vine Maple (*Acer circinatum*), Salmonberry (*Rubus spectabilis*), Red Huckleberry (*Vaccinium parvifolium*), Salal (*Gaultheria shallon*), leaf litter, ferns and mosses.

In each study area, we established a 9-ha live-trapping grid consisting of 96 (6 by 16) stations located at 30 m intervals. We set Tomahawk live-traps (model 201, Tomahawk Live Trap Co., Tomahawk, Wisconsin) at alternate trap stations, resulting in 48 traps per live-trapping grid. We live-trapped squirrels for 2 days every 2 weeks from May to August 1997 (9 trap sessions) in both study areas.

We baited the traps with sunflower seeds and set them in early morning and checked traps 4-6 hours later. Captured squirrels were ear-tagged with numbered metal tags (Monel #1, National Band and Tag Co., NewPort, Kentucky), sexed and weighed (± 5 g using a Pesola® spring balance). We noted breeding condition by palpation of male testes and female mammaries (Sullivan and Moses 1986).

We estimated population size, proportion of reproductive squirrels, body mass, and home range size. Population size and trappability were estimated for each trap session using the Jolly-Seber mark-recapture model (Jolly 1965; Seber 1965). We were not able to use radio-telemetry to estimate the territory size of Douglas's Squirrels in this study; therefore we estimated home range size by using trapping location for animals that were captured ≥ 2 times using the exclusive boundary strip method (Hayne 1949, 1950; Stickel 1954). Also, we only considered home ranges of females because in late spring and early summer, males roam extensively while searching for potential mates.

We used chi-square test to examine the trappability of squirrel populations between both sites. We used one-tailed t-test to compare densities of Douglas's Squirrels between sites. Due to unequal variances for Eastern Grey Squirrel densities in Stanley Park, we used Mann-Whitney U test to compare differences in densities between both species in the two study areas. We used two-way Analysis of Variance (ANOVA) to examine the difference in body mass and home ranges of Douglas's Squirrels between Ecological Reserve #74 and Stanley Park. The *Z*-test was used to test for significant differences in the proportion of squirrels in breeding condition (Sokal and Rohlf 1995). Since sample sizes of breeding individuals were small, the statistical power of the Z tests is very low in detecting

Table 1. Summary of demographic parameters for Douglas's Squirrels (DS) and Eastern Grey Squirrels (EGS) in Ecological Reserve #74 and Stanley Park, Vancouver, British Columbia, Canada from May to August 1997. Values shown are mean≠± SE.

	Ecological Reserve #74	Stanley Park	
	DS	DS	EGS
Density (individuals/ha)	3.5 ± 0.4	2.9 ± 0.1	2.5 ± 0.4
Home range (ha)	0.37 ± 0.096	0.44 ± 0.11	–
Trappability (%)			
Male	74.7	60.3	30.0
Female	80.9	74.0	30.0
Body mass (g)			
Male	181.8 ± 2.69	184.5 ± 3.81	608.6 ± 11.91
Female	177.4 ± 4.62	181.1 ± 4.40	603.7 ± 15.59
Proportion of breeding females (%)	20	5	77

a significant effect; however, the *Z*-statistic was used as an index of differences between study areas. All values are reported as mean ± SE.

Results

Density and home range

From May to August 1997, we captured 30 male and 24 female Douglas's Squirrels in Pacific Spirit Park. In Stanley Park, we caught 19 male and 25 female Douglas's Squirrels. Eastern Grey Squirrels were only found in Stanley Park, and we caught 22 males and 17 females. See Table 1 for a summary of demographic parameters.

Trappability of Douglas's Squirrels in Pacific Spirit Park was similar between males and females, at 74.7% and 80.9%, respectively. Male and female Douglas's Squirrels in Stanley Park also have relatively high trappability values, both ranging from 60.3% to 74.0%. On the other hand, Eastern Grey Squirrels had very low trappability, with males and females both having 30%. Trappability of Eastern Grey Squirrels was significantly lower in Stanley Park ($\chi^2 = 14.54$, df = 1, $P < 0.001$) than for Douglas's Squirrels.

Densities of Douglas's Squirrels did not differ ($t = 1.65$, df = 12, $P = 0.12$) between Ecological Reserve #74 (3.5 individuals/ha ± 0.4) and Stanley Park (2.9 individuals/ha ± 0.1). In Stanley Park, density also did not differ (Mann-Whitney T = 56, $P = 0.71$) between Eastern Grey Squirrel (2.5 individuals/ha ± 0.4) and Douglas's Squirrels (2.9 individuals/ha ± 0.1).

No effect of sex ($F_{1,64} = 0.18$, $P = 0.67$) or study area ($F_{1,64} = 1.24$, $P = 0.27$) on the home range of Douglas's Squirrels, nor were significant interactions detected ($F_{1,64} = 0.44$, $P = 0.51$). Home ranges averaged 0.31 ± 0.05 ha ($n = 96$).

Body mass and reproduction

No effect of study area ($F_{1,93} = 0.075$, $P = 0.78$) on body mass of Douglas's Squirrels was found, but there was a gender effect ($F_{1,93} = 5.41$, $P = 0.022$), with males (185.3 ± 4.1 g, $n = 48$) being heavier than females (177.2 ± 5.3 g, $n = 49$) in both parks.

For comparison purposes, Eastern Grey Squirrels in Stanley Park averaged 606.4 ± 19.1 g with no gender difference ($t = 0.25$, df = 37, $P = 0.80$). On average, male Eastern Grey Squirrels weighed 608.5 ± 11.9 g, and females weighed 603.8 ± 15.6 g.

From 20 May to 28 August 1997, proportions of female Douglas's Squirrels in breeding condition differed significantly between sites ($Z = 2.56$, $P < 0.001$), with a higher proportion of breeding females in Ecological Reserve #74 compared to that in Stanley Park: 20% (15 breeding out of 77 individuals) and 5% (3/62), respectively. In Stanley Park, the proportion of female Eastern Grey Squirrels in breeding condition (77%: 17/22) was higher than for Douglas's Squirrels (5%: 3/62). However, the proportion of breeding male Douglas's Squirrels at the two sites was similar and averaged 98.3% (59/60).

Discussion

We did not detect strong effects of exploitative competition between Eastern Grey Squirrels and Douglas's Squirrels. There was no evidence of reduced density, large ranges, and lower mass in Douglas's Squirrels where the two species co-occurred. However, the proportion of breeding Douglas's Squirrels was significantly lower in Stanley Park compared to that in Ecological Reserve #74, suggesting possible negative effects of Eastern Grey Squirrels on the breeding propensity of Douglas's Squirrels.

Densities of Douglas's Squirrels are limited by food availability (Sullivan and Sullivan 1982; Ransome and Sullivan 1997), and old-growth forests provide higher-quality habitat for Douglas's Squirrels than younger forests due to greater and more reliable quantities of conifer seed (Buchanan et al. 1990). In our study, the densities of Douglas's Squirrels were similar at both sites, suggesting that habitat suitability was similar, and further suggesting that reduced breeding propensity was caused by the presence of Eastern Grey Squirrels, and not simply an artifact of difference in food availability among study areas.

A possible explanation for weak effects of exploitative competition between the two species of squirrels could be due to the fact that Eastern Grey Squirrels often can exploit broadleaved and deciduous wood-

land to increase breeding success by feeding on high-energy food (Skelcher 1997; Gurnell et al. 2001), but since both study areas consist of mixed woods with high conifer content, advantages in breeding success of Eastern Grey Squirrels were perhaps less pronounced (Teangana et al. 2000). Thus, Douglas's and Eastern Grey Squirrels could coexist for many years although perhaps Douglas's Squirrel would slowly decline due to lower reproductive outputs (Reynolds 1985; Gurnell 1996).

Our density estimates for Eastern Grey Squirrels (2.5 individuals/ha) also were slightly higher than those reported >45 years earlier (1.7 individuals/ha; Robinson and Cowan 1954), suggesting that the population of Eastern Grey Squirrels in Stanley Park is relatively stable, even if their range elsewhere has expanded (Gonzales 1999, 2000). If the combined presence of both Douglas's and Eastern Grey squirrels in Stanley Park accelerates the depletion of the autumn seed crop, this might force a greater dependence on alternative plant foods in the spring and summer, which Eastern Grey Squirrels are better able to use because of their larger body size (Ackerman and Weigl 1970; Steele and Weigl 1993). An investigation into the feeding behavior and space use of both species would provide a better understanding of how Douglas's and Eastern Grey squirrels coexists in anthropogenic environments such as urban parks. This study highlights the need for more long-term population monitoring of the interaction of the two squirrel species in areas where Eastern Grey Squirrels were introduced.

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Responses of Syrphids, Elaterids and Bees to Single-tree Selection Harvesting in Algonquin Provincial Park, Ontario

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The species composition of hoverflies (Syrphidae), click beetles (Elateridae), and bees (Apoidea) was studied to determine whether there was a positive response in these flower-seeking insect groups to gaps in the canopy created through single tree selection harvesting of Sugar Maple (*Acer saccharum*) and Yellow Birch (*Betula alleghaniensis*) in hardwood forests of the Great Lakes-St. Lawrence forest region of Algonquin Provincial Park, Ontario. There were significantly more hoverflies and bees collected in forest stands harvested within the previous five years than in wilderness zone (unharvested at least for 40 years) stands or stands harvested 15-20 years previously (old logged stands). Click beetles, especially *Selatosomus pulcher* (LeConte), were collected most often in old logged stands. Bees and click beetles were collected significantly later in the season in logged than in wilderness zone stands. Malaise traps resulted in higher capture rates for syrphids than pan traps, and only with these higher capture rates did we detect a significant increase in species richness in recently logged stands over that in wilderness stands. Changes in the numbers and phenology of flower-visiting insects may impact on reproductive success of flowering plants of the forest understory and deserves further study.

Key Words: single-tree selection logging, syrphids, hoverflies, Syrphidae, click beetles, Elateridae, bees, Apoidea, Algonquin Provincial Park, hardwood forests.

Single-tree selection harvesting[†] in shade-tolerant hardwood forests creates cyclic perforations in the canopy on a 20-25 year rotation and is hypothesized to simulate conditions found under gap-phase dynamics. This form of silviculture is practised in many parts of the Great Lakes-St. Lawrence Forest Region in Ontario and Quebec (Hunter 1990). Very little is known about the impact on non-target species of removing 25% of the basal area of the forest through selection cutting (Annand and Thompson 1997).

Particular invertebrate groups are most likely to respond to changes in light conditions of the forest floor as a result of reductions in canopy cover. Many plants respond positively to increased light. As a result, insects with adult stages attracted to conspicuous flowers, also are expected to increase in abundance. These include bees (Hymenoptera: Apoidea), hoverflies (Diptera: Syrphidae), a family of flies that contains important flower visitors and pollinators (Waldbauer 1983; Kula 1997; Goulson and Wright 1998; Gross 2001), and many click beetles (Coleoptera: Elateridae), a less well-known group of flower visitors (Johnson 2002).

Changes in other components of the forest as a result of selection cutting may also benefit these insects. Larvae of hoverflies of the subfamily Syrphinae feed largely on aphids (Vockeroth 1992), and may benefit from increased herbaceous growth associated with canopy opening. Larvae of many elaterids (Johnson 2002) and some hoverflies of the subfamily Eristalinae (Vockeroth 1992) inhabit decaying wood. Their response to logging may depend on the availability of amounts, sizes and decay states of the standing and fallen trees remaining after each phase of the logging cycle. Soil-inhabiting elaterid larvae and ground-nesting bees may be affected by changes in vegetation, litter composition and depth, microclimate, and soil disturbance (Penev 1992; Sugar et al. 1998). Disturbance caused by construction of sand logging roads may result in greater colonization by psammophilous bees and elaterids in a previously unsuitable forest stand (Cane 1991).

We studied the impact of selection cutting on these non-target invertebrates in Algonquin Park, Ontario. We predicted positive density responses for all three groups, either as a result of an increase in spring flora, or other changes associated with logging. We also predicted that the presence of insects that visit flowers would extend later into the growing season in logged forests than in unlogged stands because of the greater amount of light penetrating to the forest floor throughout the spring and summer seasons. We tested these predictions by comparing these insect communities in

[†] Under *selection harvesting*, only some of the trees are cut in order to balance the volume of wood harvested with the amount produced through new growth and to enhance biodiversity and ecological functions. This system of silviculture differs from *selective harvesting* in which only the best timber trees are cut and the forest is gradually degraded.

stands cut 6 months to 3 years before our sampling, 15-20 years before, and in stands that have not been subjected to logging for at least 40 years.

Study Area and Methods

The study was conducted in the summers of 1997 and 1998 in Algonquin Provincial Park, Ontario (42°32'N, 78°36'W), as part of a larger study that was examining impacts of logging on birds (Jobes et al. 2004) and ground beetles (Carabidae: Vance and Nol 2003). Forest stands were chosen randomly (within the constraint that they be within 500 m of road access) in wilderness designated zones (Algonquin Park Management Plan 2000), last logged at least 40 years prior to survey), old logged (15-20 years post cutting), and recently logged (6 months – 3 years post cutting) areas. Canopy cover (estimated in July) ranged from 60-70% in the wilderness zone to 25-35% in old cut and recently cut stands, and was significantly higher in the wilderness zone stands than in both the old logged and recently-cut stands (Jobes et al. 2004). Other vegetation differences included a significant increase in vegetation under 2 m and percent logging residue cover (mostly tops of trees) in the recently cut stands over that in the other two treatments, and a significant increase in stem densities and saplings (2-5 m) and subcanopy (5-10 m) vegetation in the old logged treatments as compared to the other two (Jobes et al. 2004).

In 1997, we used a single Malaise trap set on a ridge in one stand of each of the recently logged and wilderness zone treatments. It was emptied at 1-week intervals every other week from May to August. Thus, we had no replication of stands for this year. In 1998, we set yellow pan traps (21 $cm^2 \times 5$ cm depth) filled with water to a depth of 2-3 cm, and a small amount of detergent in a total of 18 stands. These traps were set, within stands, at 100 m intervals at permanent markers. We sampled eight stands in the wilderness zone, seven in the recently logged areas, and three in the old logged areas. Stands were separated by a minimum of 200 m, but most stands were separated by > 3 km, in stands consisting of at least 75% upland deciduous forest (Vance and Nol 2003) so we assumed that they were spatially independent. Each stand contained a minimum of three traps. The sampling was uneven in the treatments because of accessibility of stands and because two of the initial old logged treatments were logged in the winter of 1997-1998. These traps were set from early May to late August, and emptied weekly for three weeks in early, mid, and late summer periods, for a total of nine trapping weeks. There were 69 incidents of trap disturbance by mammals.

Pitfall traps were used to obtain activity-density estimates for click beetles (Baars 1979). Pitfalls were constructed using 1 litre plastic 11.5 cm diameter containers lined with 500 mL plastic containers of the same diameter (Spence and Niemelä 1994). The traps were dug into the ground so that the top of the upper container was level with or slightly below the surface of the soil. Each trap was filled with approximately 300 ml of water, with a few drops of dish soap added to reduce surface tension. Two pitfall traps were set at 4 m to each side of the permanent stand markers, at the same intervals as the pan traps. In 1997, pitfalls were set for one week in each of May through August for a total of four weeks. In 1998, pitfalls were set for the same periods as the pan traps. A small number of traps (5%) were disturbed in all treatments

All invertebrates were sorted initially to class, and all but insects were discarded. Insects of the three target groups were then sorted and identified with the use of keys by Becker (1956, 1974); Brown (1934); Coovert and Thompson (1977); Curran (1921, 1922, 1925, 1934, 1941); Curran and Fluke (1926); Dietrich (1945); Fluke and Hull (1945); Fluke and Weems (1956); Hull and Fluke (1950); Michener et al. 1994; Mitchell (1960); Shannon (1939); Telford (1970); Vockeroth and Thompson (1981); and Vockeroth (1992). Voucher specimens are deposited in the Canadian National Collection of Insects and Arthropods, Agriculture and Agri-food Canada, Ottawa.

As we began sampling in all treatments at the same time, we used the dates (1998 only) on which the target groups were captured as independent samples, for our comparisons of phenology. These data were highly skewed so we used the Kruskal-Wallis ANOVA to test for significance among treatments. We were unable to use stands as sampling units for any statistical comparisons because capture rates were too low. Thus, we tested for significant differences among treatments in species and numbers of individuals trapped, using chi-square tests, with proportion of total trapping effort among treatments used to calculate expected numbers. We report standardized residuals ((Observed – Expected)/ √Expected) and their direction to show which treatment had greater or less than the numbers of individuals or species than expected based on our sampling effort (Quinn and Keough 2002). For pitfalls and pan traps we usually caught single individuals of the target species and these were spread across a range of stands within that treatment, so that the assumption of independence for this statistical test was probably not violated (i.e., the samples are not biased by many individuals caught in one particular stand and treatment except in cases where noted below). Given the low capture rate for any of our target groups we did not calculate or analyse patterns of diversity.

To assess spring ephemeral abundance, we counted, in 1 m^2 quadrats placed 5 m to the side of pitfall and pan trap locations, all visible stems of spring-blooming forb species during the first sampling period in May 1998, before canopy leaf emergence.

Results

Each of the three target groups had substantially higher captures per unit effort (combining sample across all stands per treatment because of low num-

bers captured) in at least one logged treatment than in the wilderness zone treatment (Table 1).

Syrphids. In both years, with both pan and malaise trapping methods, more species of syrphids were caught in logged than in unlogged landscapes (Table 2). In 1997, eight species were found in wilderness zone malaise traps and 25 species were trapped from the recently logged stands with three species in common between the two treatments. As Malaise traps were opened for an equal number of days in the two stands, we calculated expected numbers using the binomial distribution, based on $P = 0.5$. Significantly more

TABLE 1. Catch per unit effort (×100) for all Syrphidae, Elateridae and Apoidea caught in pan traps in recently logged, old logged, and wilderness stands in 1998, and combined catch for pitfalls in 1997 and 1998.

	Recently Logged	Old Logged	Wilderness
Total pan trap days	1894	1040	2961
Total pitfall days	4796	3088	7938
Syrphidae (pan)	0.68	2.31	0.17
Elateridae (pan)	1.37	6.82	3.71
Elateridae (pitfall)	0.27	1.49	0.30
Apoidea (pan)	3.22	2.11	1.28

TABLE 2. Species and numbers of individuals captured of Syrphidae from pan traps set in recently logged, old logged, and wilderness stands in Algonquin Provincial Park using Malaise traps in 1997 and pan traps in 1998. χ^2 statistic provided for test of association between number of individuals and species and logging treatment. Standardized residuals give direction and strength of deviation (Quinn and Keough 2002)

Species	Wilderness		Old logged	Recently logged	
Year	1997	1998	1998	1997	1998
Sub-Family Syrphinae					
Baccha elongata (Fabricius)	1	1			
Dasysyrphus pauxillus (Williston)	2				
Epistrophe nitidicollis (Meigen)				1	
Eupeodes perplexus (Osburn)		1		3	
Eupeodes americanus (Wiedemann) or *pomus* (Curran)				1	
Melanostoma mellinum (Linnaeus)		2	23	9	4
Meliscaeva cinctella (Zetterstedt)				1	
Parasyrphus semiinterruptus (Fluke)					2
Parasyrphus sp.	1				
Platycheirus confusus (Curran)	1			3	
Platycheirus obscurus (Say)				10	
Sphaerophoria novaeangliae (Johnson)				10	
Syrphus rectus (Osten Sacken)				1	
Toxomerus geminatus (Say)	1			2	
Sub-Family Eristalinae					
Brachyopa notata (Osten Sacken)				1	
Brachypalpus oarus (Walker)				1	
Chalcosyrphus nemorum (Fabricius)		1		4	2
Cheilosia rita (Curran)				1	
Cheilosia tristis (Loew)				1	
Eristalis dimidiatus (Wiedemann)				1	
Helophilus fasciatus (Walker)					1
Lejota aerea (Loew)				1	
Lejota cyanea (Smith)				3	
Neoascia distincta (Williston)					
Pipiza femoralis (Loew)					1
Rhingia nasica (Say)	2		1	4	
Sericomyia chrysotoxoides (Macquart)				1	1
Sphegina brachygaster (Hull)					1
Sphegina flavomaculata (Malloch)	1				
Sphegina keeniana (Williston)				2	
Sphegina campanulata (Robertson)				2	
Temnostoma balyras (Walker)				1	
Volucella bombylans (Linnaeus)				1	
Xylota quadrimaculata (Loew)					1
Xylota confusa (Shannon)					3
Number of individuals $\chi^2 = 45.9$, $P < 0.001$	11	5	24	66	16
Standardized residuals, individuals (1998 data only)		-3.7	2.0		0.42
Number of species $\chi^2 = 5.5$, n.s.	8	4	2	25	9
Standardized residuals, species (1998 data only)		-1.3	-0.4		1.9

syrphid individuals and species were captured in the Malaise trap set in the recently logged than in the wilderness habitat (Binomial test, species: $P < 0.0001$, individuals: $P < 0.0001$). In 1998, using pan trap catches, two species, each consisting of one individual each, were found only in the wilderness zone, whereas nine species were found only in the recently logged landscape. Only six species were found in both years using the two capture techniques. Significantly more individuals were caught in 1998, in the old logged stands than in either the recently logged or wilderness treatments (Table 2), but this result was entirely due to a capture of 17 individuals of the species *Melanostoma mellinum* on 14 May 1998 in the old logged treatment.

In 1997, we did not begin sampling until late May, after leaf-out in the park. In 1998, there was a strong bias in the collection times for all syrphids, with 16 of 22 collection dates for syrphids (73%) in May, prior to leaf-out. There was, however, no significant difference among treatments in the collection dates of syrphids in 1998 (median sample dates (range): wilderness: 29 May (26 May-6 August), $n = 5$ trap sample dates; old logged: 21 May (14 May-2 July), $n = 4$; recently logged: 27 May (9 May-24 June), $n = 13$, Kruskal-Wallis $\chi^2 = 4.33$, $P = 0.11$).

Bees. Twelve species of bees were identified, with five of these from wilderness and old logged stands and all twelve in the recently logged stands (Table 3). All but four species (excluding *Andrena*) were halictids. For both number of species and number of individuals the recently logged stands had significantly more bees than expected based on catch effort (Table 3).

All but 6 of the 57 dates on which we captured bees were in May. Bees were caught at a significantly later date in recently logged stands than in either old logged or wilderness stands (median collection dates (range): wilderness: 10 May (8-20 May), $n = 18$ trap sample dates; old logged: 9 May (9 May-24 June), $n = 13$; recently logged: 19 May (9 May-14 July), $n = 26$, Kruskal-Wallis $\chi^2 = 13.8$, $P < 0.001$).

Elateridae. In this group of insects, two species, *Ctenicera triundulata* and *C. vulnerata* were found only in the wilderness stands, both in very low numbers (Table 4). The number of species among treatments did not deviate from expected using the pan trap data but was marginally higher than expected in the old logged treatment using the combined 1997/1998 pitfall data (combined years due to small sample sizes, $\chi^2 = 5.89$, $P < 0.06$).

Numbers of individual click beetles were significantly higher in the old logged habitat, and significantly lower in the wilderness zone than expected based on catch effort, using pan traps and pitfall traps (Table 4).

Elaterids were collected in 1998 from pan traps at significantly later dates in old logged and recently logged stands than in wilderness zone stands (median date (range); wilderness zone: 13 May (8 May-5 June), $n = 9$; old logged: 28 May (8 May-9 July), $n = 23$; recently logged: 19 May (9 May-2 July), $n = 23$; Kruskal-Wallis $\chi^2 = 7.6$, $P = 0.02$). Using 1998 pitfall data, elaterids were sampled significantly later in recently logged stands than in the other two treatments (wilderness zone: 17 May (13 May-4 August), $n = 20$; old logged: 17 May (14 May-3 July, $n = 22$; recently logged: 24 June (12 May-24 June), $n = 9$; Kruskal-Wallis $\chi^2 = 6.34$, $P = 0.04$). The 1997 elaterid data were too sparse for analysis.

Spring ephemerals. We recorded 15 species of spring ephemerals in our quadrats (1998 only). The numbers of ephemerals found in all of the stands were extremely variable (cv's range from 156-165%). Although the mean number of stems in the recently logged stands was more than twice as large as this number in wilderness zones, there was no significant difference among treatments (recently logged: 59.7 ± 16.7 / m^2, $n = 23$ plots; old logged: 46.5 ± 22.1 / m^2, $n = 13$ plots; wilderness zone: 26.5 ± 18.8 / m^2, $n = 18$ plots; $F_{2, 51} = 0.88$, n.s.).

Discussion

Our results suggest that all three of groups of flower-visiting insects were more abundant in one of the logged habitat types than in the wilderness zone. This suggests that these insect groups were positively affected by single-tree selection harvesting as it is practised recently and/or how it was practised in the 1970s, when the selection cuts were heavier than is currently acceptable (Algonquin Forestry Authority, unpublished). This result is not explained simply by greater numbers of spring ephemerals, as, at least with our sampling methodology, we found no significant difference among treatments in the availability of flowers measured prior to leaf-out. Differences were apparent in number of individual insects, but, in general, not in insect species richness, except in the case of the Malaise traps set in 1997, where both numbers of individuals and species richness were higher in collections from the trap in the recently logged stand. Given that this result is for one trap only in each treatment, this result should be viewed cautiously.

As many larval syrphids prey on Homoptera in herbaceous vegetation and many adults feed on nectar sources in this vegetation, the presence of much higher percent cover of herbaceous or soft woody vegetation (37 to 43% in old logged and wilderness stands respectively, to 78% in recently logged stands, particularly *Rubus idaeus* L. var. *strigosus* (Michx), Jobes 1999) could explain the significant increase in syrphid abundance that we found through Malaise trapping. An apparent increase also was noted in our pan trapping results but not established statistically because of the generally poor success of this method for capturing syrphids in any of our stands. A similar positive numerical response in syrphids (also not tested statistically) was found in Poland's polluted spruce forests,

TABLE 3. Species and Genera of bees collected from pan traps and numbers of individuals and minimum number of species from Algonquin Park, summer 1998. 122 individuals captured. Statistics and standardized residuals as in Table 2.

Genus	Wilderness	Old logged	Recent logged
Andrena[1]	36	20	21
Bombus perplexus Cresson		1	6
Bombus vagans Smith			
Hylaeus elliptica (Kirby)			1
Lasioglossum admirandus (Sandhouse)	1		9
Lasioglossum divergens (Lovell)	1		1
Lasioglossum laevissimus (Smith)		1	6
Lasioglossum nymphaearum (Robertson)			1
Lasioglossum quebecensis (Crawford)			1
Lasioglossum rohweri (Ellis)			10
Lasioglossum versans (Lovell)		1	3
Lasioglossum zephyrus (Smith)			1
Osmia atriventris Cresson			1
Number of individuals $\chi^2 = 21.2$, $P < 0.001$	38	23	61
Standardized residuals, individuals	-2.9	0.3	3.5
Minimum number of species $\chi^2 = 20.4$, $P < 0.001$	3	4	12
Standardized residuals, species	-1.2	1.3	4.2

[1] Not identified to species because of poor quality of specimens.

TABLE 4. Species and number of individuals of Elateridae collected from wilderness, old logged stands, and recently logged stands in Algonquin Park in 1997 and 1998 using pan traps (individuals: $\chi^2 = 175.1$, $P < 0.00$); species: $\chi^2 = 3.2$, n.s.) and pitfall traps (individuals: $\chi^2 = 90.7$, $P < 0.001$, species: $\chi^2 = 5.9$, n.s.). Analysis for pitfalls from two years combined). Standardized residuals as in Table 2.

	Wilderness			Old logged			Recent logged		
Species	98 Pan	97 Pit	98 Pit	98 Pan	97 Pit	98 Pit	98 Pan	97 Pit	98 Pit
Agriotes collaris (LeConte)	2		1	5		6	1		3
Agriotes stabilis (LeConte)						1			
Athous acanthus (Say)					1				
Ctenicera hieroglyphica (Say) ((Say))	1	2	2						1
Ctenicera insidiosa (LeConte)								1	
Ctenicera resplendens (Eschscholtz)			1			1			
Ctenicera spinosa (LeConte)			1			1			
Ctenicera triundulata (Randall)		2							
Ctenicera vulnerata (LeConte)	1								
Dalopius cognatus Brown				1			1		
Dalopius fuscipes Brown			1		1			1	
Dalopius spp. (females)			2	2		1	3		2
Limonius aeger LeConte							2		
Limonius confusus LeConte	5	1	1	4	1	2	9		3
Melanotus castanipes (Paykull) (Paykull)							1		
Neohypdonus tumescens (LeConte)			1		1	2			
Selatosomus pulcher (LeConte)	2		10	59	2	28	10		
Number of individuals	11	5	20	71	6	42	27	2	9
Standardized residuals, individuals	-3.4	-2.6		11.8	8.6		-1.3	-3.1	
Number of species	5	3	9	5	5	8	7	2	4
Standardized residuals, species	-1.2	-0.8		1.1	2.2		0.7	-0.6	

as an apparent result of drastic reductions in canopy cover and greater herbaceous and grass undergrowth (Kula 1997). Some species of at least two genera of hoverflies that were found in the wilderness zone (*Melanostoma* and *Platycheirus*) specialize on graminoid and other anemophilous pollen, enabling them to be active later into the spring/summer when graminoids typically flower (Vockeroth 1992; Gilbert 1993). However, none of the species captured is restricted to flying in the spring.

Bees, like syrphids, were most abundant in the recently logged areas. Unlike syrphids, larval bees are fed pollen and thus are more wholly dependent on floral resources. Some bees also may be affected by the

availability of open flight paths present in the open understory of the recently logged treatments, to make pollen-gathering trips for brood provisioning, although the effects of forest habitat on bee movement is probably species-specific, and for many species these movement patterns are unknown (Kreyer et al. 2004). Woodland and edge ground nesting bees (the majority of the species caught in the recently logged stands) are thought to benefit from patches of disturbed habitat associated with habitat fragmentation (Cane 1991) and thus, may benefit from the building of sand logging roads. Halictid bees can be major components of pollinator communities in other forest types (Pascarella 1997). Their role in northern hardwood forests has not been adequately assessed.

Elaterids were most abundant in the old logged habitats, using two methods of sampling, indicating positive responses to the much higher cover of the sapling (2-10 m) layers found in this treatment (Jobes et al. 2004). The most abundant species, *Selatosomus pulcher*, has been trapped in open field habitats (Boiteau et al. 2000). This species is morphologically nearly indistinguishable from the European species *C. cruciatus*, a species whose larvae develop in the sandy and moist soils in forest and forest edge (Leseigneur 1972). The higher abundance of elaterids in the old logged treatment areas may be due largely to this species' positive response to the edge-like conditions present in this treatment. The lower numbers of elaterids in the recently logged stands may indicate the absence of colonization because of the short time frame. Analagous results are suggested in a study of herbaceous plants in recently logged White Pine (*Pinus strobus*) stands in Algonquin. Plants in those stands were most similar to plants in unlogged stands presumably because there had been insufficient time for changes in community assemblages after the logging (Kingsley 1998).

As little is known about the role of adult food availability in the distribution of elaterids, the near significant positive effect on species richness may also be due to the greater availability of soil invertebrates or plant material suitable for larval food produced by a four-fold increase in the number of stumps in old logged versus either wilderness or recently logged stands (Jobes 1999).

Of the two elaterids caught only in the wilderness treatment, only one may be an old growth dependant species. *Ctenicera vulnerata* (1 specimen caught) has rarely been collected, and has not been reported previously from Ontario. The other, *Ctenicera triundulata* (2 specimens) cannot be considered old growth-restricted, as it has been collected in moderate numbers in an apparently healthy spruce (*Picea* sp.) in an old field by HD.

We found very few bees, syrphids or click beetles in our samples from the wilderness zone stands, although we expected to find some, at least early in the season when the canopy had not yet leafed out or of species that utilized downed woody debris (e.g., *Chalcosyrphus*, *Xylota*, *Brachyopa*). The reason for their paucity in the wilderness zone is unclear but deserves further study.

The numerical increase and changes in phenology of flower-associated insect species suggests the potential for greater pollinator efficiency in logged forests, and hence greater reproductive success, through greater seed set of flowers. A more detailed examination of species-specific patterns of habitat use by pollinators and their functional role in hardwood forests is worthy of future research (e.g., Sheffield et al. 2003; Kreyer et al. 2004).

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New Nesting Records of the Le Conte's Sparrow, *Ammospiza leconteii*, from Northeastern Ontario, with Some Notes on Nesting Behaviour

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Patrikeev, Michael. 2006. New nesting records of the Le Conte's Sparrow, *Ammospiza leconteii*, from northeastern Ontario, with some notes on nesting behaviour. Canadian Field-Naturalist 120(1): 22–26.

Le Conte's Sparrow is sparsely distributed through northeastern Ontario with no confirmed records from Algoma District and eastern Lake Superior. Two nests were found in open poor fen between Wawa and Hawk Junction in central Algoma District in 1999. Notes on behaviour, nests, nestling development and feeding effort were taken during 9 hours and 38 minutes at one nest over three days.

Key Words: Le Conte's Sparrow, *Ammospiza leconteii*, nesting, northeastern Ontario.

Le Conte's Sparrow (*Ammospiza leconteii*) is distributed through grasslands and wetlands of central and southern Canada east to Ontario and Quebec, and in the north-central United States. "It is one of the least known North American sparrows and any new information on this species may be of interest" (Lowther 1996). A cryptic species, it nests in thick clumps of dead grass, and its nests are difficult to find. Only about 50 nests had been recorded range-wide by the early 1960s (Walkinshaw 1968) and few have been documented since then (Lowther 1996). Only nine nests of this species had been found in Ontario prior to 1999 (Peck and James 1987; Sandilands and Campbell 1987; G. Peck, personal communication). In Ontario, Le Conte's Sparrow has been reported in widely separated areas in the forest zone with the greatest concentrations in the James Bay Lowland and northwestern Ontario (Sandilands and Campbell 1987). During the first Ontario Breeding Bird Atlas (1981-1985) this species was found in only 20 of 137 UTM blocks (100 × 100 km) and nesting was confirmed in only four blocks (Sandilands and Campbell 1987). None of the first Atlas records were from Algoma District, although Le Conte's Sparrow was considered a rare spring species in the vicinity of Wawa (Ontario Ministry of Natural Resources 1990). In 2001-2004, surveyors for the second Ontario Breeding Bird Atlas reported probable nesting in two blocks (Sault Ste. Marie and St. Joseph Island), and possible nesting in five additional blocks in the vicinity of Sault Ste. Marie and Thessalon at the south end of Algoma District (Ontario Breeding Bird Atlas website: http://www.birdsontario.org/atlas).

Here I describe two new nests from central Algoma District, northeastern Ontario. A small group with 2-3 singing males was found in an upland wetland (5.8 ha, 48°02'42.24N", 084°34'01.30W") in Esquega Township east of Wawa and southwest of Hawk Junction (Figure 1). The wetland (329 m above sea level) encompassed elements of several wetland types gradually changing from sphagnum bog with few stunted Black Spruce (*Picea mariana*) to open poor fen and then to a meadow marsh (Harris et al. 1996).

Le Conte's Sparrows inhabited approximately 2 ha of open poor fen in this wetland (see Figure 2). The wetland was bordered by alder thickets (Speckled Alder, *Alnus incana*) with a few dead Balsam Poplars (*Populus balsamifera*) and by mixed forest dominated by Trembling Aspen (*P. tremuloides*) and White Birch (*Betula papyrifera*). Water regime of the wetland changed from late May through July 1999. The lower parts (mostly meadow marsh section) were flooded in late May (up to 0.5 m deep), but water gradually receded by late June. The area remained damp, but no standing water remained (natural flow in this wetland was likely disrupted years ago when it was transsected by Highway 101). The area occupied by Le Conte's Sparrows had a ground cover of sphagnum moss and was dominated by two species of sedge: Few-seeded Sedge (*Carex oligosperma*) and Awl-fruited Sedge (*C. stipata*); Canada Bluejoint (*Calamagrostis canadensis*) was also present.

Singing males were heard at the wetland on 21 May 1999, and a display flight observed on 27 May. A flight song is described by Murray (1969). I also observed a "spy flight": a sparrow would rise from the grass and fly in a low arch quickly dropping back into the cover. Le Conte's Sparrow likely uses this flight to determine precise position of an approaching intruder. No song or audible call was uttered during such flight.

Two nests were found in the wetland, on 13 June and 17 July 1999, respectively. The first nest contained five eggs (Figure 3), but was empty on 17 June. The eggs matched a description of Le Conte's Sparrow eggs from Walkinshaw (1968). The second nest contained five newly-hatched young on 17 July and still contained five young on 23 July when the young would be seven days old. On day seven, the young were in cinnamon-coloured plumage with dark streaks on the back, dark

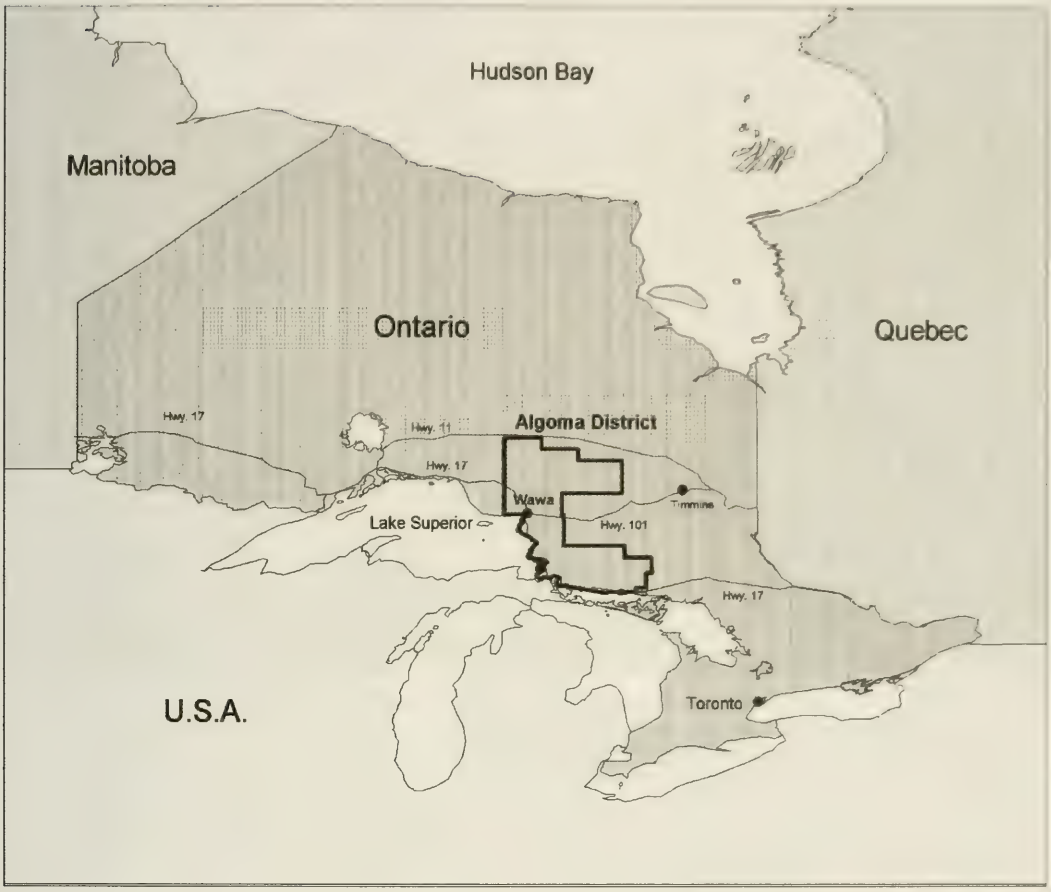

FIGURE 1. Position of Wawa and Algoma District in Ontario.

grey crowns and cheeks, tan median crown-stripe and black shafts. The median crown-stripe was seen in at least some chicks (Figure 4). Bill colour changed from fleshy on days two-three to grey-pink on day seven. Gape was bright flesh red on day seven. According to Gollop et al. (1966), the young leave the nest at the age of seven days.

The two nests were approximately 150 m apart and might have belonged to the same pair. Both nests were built of dried stems, and lined with fine dried stems of sedge and grass. Outer rim of both nests was loosely built. The first nest was well hidden under and inside a clump of dried graminoids and could not be seen from above. The second nest was attached to dried and living sedge stems and a small Leatherleaf (*Chamaedaphne calyculata*) under a loose cover of sedges and grasses. Both nests were 5-6 cm above the wet ground.

Observations totaling 9 hours and 38 minutes were made at the second nest from a blind (through a telephoto lens) during late afternoon-early evening hours on 19 July (1610-2045 hours), 21 July (1800-2110) and 22 July (1812-2005). All observations were conducted during calm fair weather. The pair at the nest under observation consisted of a slightly larger brighter male, and a scruffier duller female. Le Conte's Sparrows never flew directly to and from the nest, but landed some distance away and walked (hopped) to it, fed the young and walked away before taking on the wing. Also both birds were never present at the nest at the same time during the observation period. A total of 80 feeding visits was recorded. The birds were bringing food every 6.6 minutes on average (SD ± 5.2, Standard error 0.6). Lowther (1996) reported 1 feeding/minute at a nest containing a cowbird. Gender of feeding birds was assumed on 55 occasions. The male fed the young on average every 14.1 minutes (SD ± 13.5) and the female every 13.5 minutes (SD ± 13.5). No differences between sexes were detected in feeding efforts ($P = 0.50$). Intervals between feedings became shorter as the young were growing: every 7.9 minutes ± 5.9 on 19 July, 5.7 ± 4.6 on 21 July and 4.9 ± 3.0 on 22 July (Kruskal-Wallis one way ANOVA: $P = 0.07$).

FIGURE 2. Habitat of Le Conte's Sparrow in Esquega Township: this wetland encompassed elements of several wetland types gradually changing from a sphagnum bog to open poor fen and then to a meadow marsh. Le Conte's Sparrows inhabited about 2 ha of open poor fen. Photo by Michael Patrikeev.

FIGURE 3. Nest of Le Conte's Sparrow with five eggs. The nest was built of dead stems, and lined with fine stems of sedge and grass. It was well hidden under and inside a clump of dead graminoids and could not be seen from above. Photo by Michael Patrikeev. 13 June 1999.

FIGURE 4. Nestlings of Le Conte's Sparrow seven days old. Photo by Michael Patrikeev. 23 July 1999.

Lowther (1996) noted that hardly any information was available on this species' diet. Although in many cases food brought to the young was too small to identify through a telephoto lens, I observed small green caterpillars, a white moth, a spider, a small sphinx caterpillar and two grasshopper abdomens. The last three items were brought by the female who tried to feed them to the small young. The content of the sphinx caterpillar was eventually squeezed into the young's mouths, and one grasshopper abdomen was swallowed by the female itself after futile attempts to feed it to the young.

I did not observe wetlands similar to the one described above in the Wawa area (Michipicoten and Esquega townships, and the adjacent parts of Lake Superior Provincial Park) in 1999-2000 and no Le Conte's Sparrows were detected in other visited wetlands. However, this species likely occurs in low densities throughout Algoma District where suitable habitat is available.

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Conditions for Sexual Interactions Between Wild Grey Wolves, *Canis lupus*, and Coyotes, *Canis latrans*

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Genetic evidence for the hybridization of wild Grey Wolves and Coyotes was first reported by Lehmann et al. (1991). Subsequent genetic and landscape-environmental analyses have attempted to grasp the extent of Wolf-Coyote crosses in North America. Since Wolves are normally territorial and thus aggressive towards Coyotes, hybridization events remain rare, not withstanding the taxonomic debates regarding *Canis* in eastern Ontario. In this paper I report on amicable interactions between Wolves and Coyotes observed in Wisconsin in recent decades and discuss circumstances that may lead to pairing between individuals of the two species.

Key Words: Grey Wolf, *Canis lupus*, Coyote, *Canis latrans*, interactions, hybridization, Wisconsin, Upper Great Lakes region.

Wolves and Coyotes can hybridize in captivity (Young and Goldman 1944; Silver and Silver 1969; Kolenosky 1971; Schmitz and Kolenosky 1985a, 1985b). Previously it was assumed that behavioral barriers prevented hybridization between *Canis* species (Wolf × Coyote) in the wild. Evidence of such crosses in the wild remained elusive until Lehman et al. (1991) reported on the presence of Coyote genes in Wolf mitochondrial DNA material from the Upper Great Lakes region of North America probably from crosses between female Coyotes and male Wolves. This stimulated further investigations (Roy et al. 1994; Pilgrim et al. 1998; Boyd et al. 2001; Wayne et al. 1995; among others), confirming the introgression of Coyote genes in Wolf mtDNA in a region extending from the western Great Lakes east to Quebec.

Confounding these findings, recent DNA studies among *Canis* in eastern Ontario and northeastern United States hypothesize the existence of a unique and putative Eastern (Timber) Wolf *(Canis lycaon* (Wilson et al. 2000, 2003) while other researchers argue the possibility that the Eastern Wolf is the Red Wolf (*Canis rufus*), or some type of a Wolf (*Canis lupus*) × Coyote hybrid (Schmitz and Kolenosky 1985a; Wayne et al. 1995; Nowak 2003; Wayne and Vila 2003; Phillips et al. 2003; Sears et al. 2003; among others).

It is speculated that the tumultuous ecological upheavals caused by Eurasian settlement of North America disrupted *Canis* communities creating conditions facilitating hybridization (Wayne et al. 1995; among others). Forest fragmentation and heavy exploitation of *Canis* populations are believed responsible for current hybridization between various *Canis* communities in southeastern Ontario (Sears et al. 2003; Theberge and Theberge 2004).

The question remains under what environmental – behavioral circumstances did (do) unions between Coyotes and Wolves occur, given the usual aggressive tendencies of Wolves to Coyotes? Lehman et al. (1991) believed that initial hybridization most likely occurred when young, male Wolves dispersed into an area with an endemic Coyote population where female Wolves were rare. I report encounters between Coyotes and Wolves in Wisconsin that support this theory during a period when Wolves were re-colonizing landscapes occupied by Coyotes. Because of the ongoing debate over *Canis* affinities in the east, I confine my comments to the Upper Great Lakes region of North America.

Methods

It is generally accepted that two taxonomically distinct wild canid species occur in Wisconsin: Grey Wolves *(Canis lupus)* and Coyotes *(Canis latrans)*. Natural re-colonization of Wolves in Wisconsin began in the mid 1970s from expansion of the Minnesota population (Mech and Nowak 1981; Thiel and Welch 1981). Wolf monitoring has been conducted since 1979 in Wisconsin involving techniques that include a combination of winter track surveys, aerial surveillance of radio-collared Wolves, summer howl surveys, and collection of reports by government employees and citizens (Wydeven et al. 1995). The following cases of Wolf-Coyote interactions are derived from visual observations from both ground and aerial surveillance, and from interpretation of trails in snow.

Results

Florence County

Trails, raise-leg urinations (RLUs) and radio telemetry data indicated that three lone male Wolves occupied home ranges near one another in western Florence County (45°50'N, 88°50'W) in northeastern Wisconsin between 1982 and 1984. At that time 17 – 25 Wolves lived in 2-4 packs along the Minnesota-Wisconsin border (46°15'N, 92°00'W), and in two north-central Wisconsin packs, 150 km southeast of the border

area (45°30'N, 90°00'W). The Florence County Wolves were 100 km east of the two north-central packs. One of these Wolves, male 077, was captured and collared, and aerially radio-monitored about once-weekly for 250 days between 6 May 1983 and 11 January 1984, occupying a 44 km^2 home range.

Several citizen and US Forest Service reports involved sightings of a Coyote trailing a lone Wolf in the areas occupied by the lone male Wolves. Wolf Project personnel also observed snow sign indicating that lone Wolves and Coyotes interacted. On 17 February 1982, Wolf Project technician, Larry Prenn, and I followed the trail of a Coyote and Wolf over 3 km. We were not able to ascertain the timing of each canid's travel, but based on highly convoluted trail maneuvers, it appeared they were traveling together. The Wolf was likely a male (RLUing) and the Coyote was a female (squat urinations, including one with blood).

On 6 December 1983, while homing in on the signal of Wolf 077 using a Cesna 180 fixed-wing aircraft, pilot Dan Doberstein and I saw a pair of canids lying within 15- 20 m on the ice of Halsey Lake. One appeared 2 or 3 times larger than the other. After determining that neither was Wolf 077, we began a slow descent. When approximately 200 m above them, the smaller canid stood up and quickly ran off into thick lowland conifer cover. We identified it as a Coyote. As it disappeared into cover, a third, larger canid ran from shore to where the second canid was still lying. On our third pass we approached within 10 m of these canids; the second one was larger, and we agreed they were both Wolves. Shortly thereafter we located Wolf 077 male 9.6 km to the east.

The following morning we attempted to inspect their trails, but high winds overnight and thin ice made interpretation challenging. We found outlines of two large tracks corresponding in size to Wolf, and one small Coyote-sized track. No evidence of a kill-site was found that might have attracted the two species.

Wood County

In each of seven winters between 1995 and 2002 high school students under my supervision followed the snow trails of a non-collared male Wolf, 501 that had escaped into the 36 km^2 Sandhill Wildlife Area (SWA) in Wood County (44°17'N, 90°10'W) (Thiel 2000; Thiel unpublished data) in May 1995. This is a deer research facility enclosed by 3 m tall × 29.5 km long fence. At that time, Wolves were colonizing this portion of west-central Wisconsin. In winter, 1996-1997, a territorial pair of Wolves colonized the area surrounding SWA. In January 1998, a pair of Wolves believed to be yearling siblings, entered SWA, and subsequent snowfall prevented them from digging out beneath the fence and leaving. Wolf 501 paired with one of these Wolves, a female based on bloody urine discovered on 20 January 1998. The third Wolf thereafter roamed the area as a loner.

In March a 6.5 year-old radioed Coyote was killed by Wolves within SWA. Likely, Wolf 501 male was involved in its death. Wolf 501 was last observed with another Wolf in October 1998. In four additional winters of snow tracking, Wolf 501 was the only Wolf detected within SWA.

On 22 January 2001, High School students reported trailing Wolf 501 male and encountered where the Wolf had physically interacted with a Coyote, resulting in an injury to the Wolf's right front foot. On 5 February several students and I encountered Wolf 501 male's trail where it intersected a Coyote's trail, heading in the same direction. In backtracking we determined the Coyote was a proestrus female based on bloody urine.

The mutual trail led to a 5 m × 5 m site completely padded down with Wolf and Coyote tracks. Numerous small droplets of blood and several tufts of canid fur were found in the padded-down site. Genetic testing to ascertain the species leaving the blood and fur was cost-prohibitive. By carefully back-trailing and following the tracks of both the Coyote and Wolf 501 male as they left the site we established the Wolf had been injured by the proestrus Coyote at the padded down site.

The Coyote and Wolf walked on the same trail for approximately 1 km beyond the padded down site before separating. Bloody Coyote urine was noted three times along this trail, and the Wolf inspected each. At one spot along the trail the Coyote and Wolf sat down within 1.5 m of each other. We followed the Wolf an additional 3.2 km after their trails separated. The Wolf RLU'd 8 times, and in each of five beds we found the imprint of his bloody limb.

It was evident that both canids were present together and spent considerable time at the padded down site. Since we found no evidence of prey remains, and since Wolf 501 male did not react aggressively when injured by the proestrus Coyote we concluded that his injury was caused by unwanted sexual advances.

At approximately 0830 (CDT) on 22 June 2001, amateur wildlife photographer, Rudi Van Stedum, saw male Wolf 501 male standing on rock talus in a forest in SWA at a distance of approximately 50 m. The Wolf was watching her as she idled her car along a woods trail. Simultaneously Van Stedum saw movement obliquely behind and left of the Wolf. A Coyote approached but retreated when it became aware of her car. Meanwhile, the Wolf turned and left the rock, facing her. At that point, the Coyote again approached the Wolf from behind and thrust its muzzle forcefully into the left rump of the Wolf. A yelp from the Wolf was clearly audible while the Wolf's gaze remained fixed on Van Stedum. The Coyote stepped back, and both stood still for a moment before the Wolf walked a ways off and turned momentarily to look at her. As the Wolf began slowly walking away, the Coyote approached it from behind and jabbed it a second time in its left hip with its muzzle. The Wolf yelped again. Both then trailed off into the undergrowth.

Wildlife biologist Wayne Hall and I inspected Van Stedum's photographs, and while they were taken in poor light conditions and no single frame showed both the Wolf and Coyote, the position of trees in the background of all photographs attested to the accuracy of her observation. Wolf 501 male roamed SWA alone in winter 2001-2002 and disappeared sometime after October 2002. No evidence of hybrids materialized subsequent to the observations in 2001.

Discussion

Coyote mtDNA in Wolves was calculated as the result of six hybridization episodes between male Wolves and female Coyotes (Lehman et al. 1991); Wayne and Vila (2003) speculated that, "... female wolves and male coyotes are more closely matched in size, and thus may also be more likely to mate...", but they further noted that no Coyotes sampled had Wolf-like haplotypes.

Several researchers have speculated that male Wolf dispersers provide the potential pool for male Wolf × female Coyote unions (Lehman et al. 1991; Wayne and Vila 2003; among others). While probably true, this is not necessarily because male Wolves disperse beyond the edge of Wolf range, as is implied. During winter 1983-1984, Michigan and Wisconsin DNR biologists discovered several lone male Wolves living in a several thousand square kilometer area. Some of these Wolves, like Wolf 077, seemed to have home ranges, as evidenced by RLU'ing (R. Thiel and J. Hammill, unpublished notes). They likely originated from at least 100 km away where the nearest known packs then existed. But female Wolves also dispersed to this area. In summer-fall 1986 radio-collared female Wolf 035 dispersed from Douglas County, Wisconsin (46°15'N, 92°00'W) 277 km to Iron County, Michigan (46°20'N, 88°59'W) and settled into a 174 km^2 home range, becoming the first known Wolf to reach upper Michigan since their demise in the late 1950s (Thiel 1988). The first breeding Wolf pack in upper Michigan would establish itself within this same area in 1990-1991 (J. Hammill, personal communication, 1 March 2004), implying that other female Wolves also dispersed to this region. The male Wolf × female Coyote hybridization hypothesis is therefore not explained in our region by any superior dispersal advantage displayed by male Wolves.

Because of their size, Wolves can easily overpower and kill Coyotes. Ballard et al. (2003: page 267, Table 10.4) summarized Wolf-Coyote interactions in Yellowstone National Park and noted that 11 percent of interactions resulted in killed Coyotes. In fatal encounters, the number of Wolves exceeded the number of Coyotes. Wisconsin biologists have also encountered aggressive interactions between Wolves and Coyotes, including killings of Coyotes. Killings involved superior numbers of Wolves (R. Thiel, unpublished data). In contrast, the few observations of single Wolf and Coyote encounters are not known to have resulted in killings. In the fall of 1981 pilot Jim Dienstl and I watched dispersing lone male Wolf 023 chase a Coyote from a White-tailed Deer (*Odocoileus virginianus*) fawn kill, but made no attempt to catch or kill it. SWA male Wolf 501 likely killed at least one Coyote when paired with a female Wolf. Four years later, this same male Wolf - who remained a loner in those four years - consorted with one or more Coyotes on at least three occasions; one case involving a proestrus female Coyote.

As in the Wisconsin cases reported here, Michigan DNR biologist, J. Hammill (personal communication, 1 March 2004), witnessed two separate incidents where a single Wolf and Coyote apparently traveled and bedded down together during the early years of Wolf recolonization.

Within Wolf range, owing to the aggressive stance pack Wolves normally display towards foreign Wolves and Coyotes (Arjo and Pletscher 1999; Ballard et al. 2003), hybridization events must be exceedingly rare. Observations reported here indicate that single Wolves are capable of genial behavioral interactions with Coyotes. Further, they suggest a potential for sexual advances of male Wolves towards female Coyotes, when and where male Wolves lack access to female Wolves. Unions between male Wolves and female Coyotes probably remain localized (however, note Schmitz and Kolenosky 1985a; Sears et al. 2003; and Theberge and Theberge 2004), and likely occur in areas of exceedingly low Wolf densities where access to female Coyotes by single male Wolves far exceeds access to female Wolves. Under such circumstances, hybridization is at least possible, and then depends on the behavioral nuances of these canids as individuals.

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Multiple Scale Den Site Selection by Swift Foxes, *Vulpes velox*, in Southeastern Colorado

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Kitchen, Ann M., Eric M. Gese, and Sarah G. Lupis. 2006. Multiple scale den site selection by Swift Foxes, *Vulpes velox*, in southeastern Colorado. Canadian Field Naturalist 120(1): 31–38.

Predation by Coyotes (*Canis latrans*) is a major source of mortality in Swift Fox (*Vulpes velox*) populations. Year-round den use by Swift Foxes is likely to be a predator avoidance strategy. Due to the importance of denning to Swift Fox ecology, we recorded den site selection of Swift Foxes in southeastern Colorado. Den site selection was recorded at two scales: microhabitat characteristics at the den and den placement within the home range. The number of den entrances, height and width of each entrance, aspect, hill position, slope, percent rock in soil, vegetative cover, and horizontal foliar density of 42 Swift Fox dens were examined during December 1999 – April 2000. This was compared to the same microhabitat characteristics at 42 random sites within Swift Fox home ranges to determine if Swift Foxes were using site characteristics according to their availability. Our results indicated that Swift Foxes were not highly selective of den sites based on the microhabitat characteristics evaluated in this study, although Swift Foxes selected areas of intermediate rock percentages. In addition, Swift Foxes were radio-tracked throughout the sample period and the location and frequency of use of known dens were recorded. Within the core area of home ranges, Swift Foxes used more dens (mean = 3.51 ± 1.70 (SD)), and had a higher frequency of use of dens (mean = 8.20 ± 6.01) than in the mid-range area (number of dens, mean = 0.90 ± 0.94; frequency, mean = 1.27 ± 2.12) and the boundary area (number of dens, mean = 0.34 ± 0.53; frequency, mean = 0.45 ± 0.93) of the home range. We discuss our results in terms of the importance of dens in facilitating escape from Coyotes. These results illustrate the need for examining den site selection at multiple scales to determine all selection factors, and to provide information useful for recovery and management efforts for this species.

Key Words: Swift Fox, *Vulpes velox*, denning, habitat selection, home range use, Colorado.

Introduction

The Swift Fox (*Vulpes velox*) is native to the short and mid-grass prairies of North America. The current range of the Swift Fox is much reduced from the historic range, and the species was formerly a candidate for endangered species listing (United States Fish and Wildlife Service 1996). The Swift Fox has been locally extirpated in the northern prairies in Canada, North Dakota, and much of South Dakota (Scott-Brown et al. 1987). One of the principal causes of Swift Fox population declines across much of the historical range is a reduction in suitable habitat (Hillman and Sharps 1978).

The combined availability and distribution of suitable den sites and escape holes is likely a habitat component for Swift Foxes (Egoscue 1979; Rongstad et al. 1989; Herrero et al. 1991). Swift Foxes were referred to as the "burrowing fox" by Lewis and Clark and are considered one of the most fossorial canids in North America because they use dens throughout the year (Kilgore 1969; Egoscue 1979). Swift Foxes spend the majority of diurnal hours in dens or near den entrances, often concurrently with a mate (Cutter 1958; Kitchen et al. 1999). Denning might enable Swift Foxes to maintain homeostasis by providing a cool, damp microhabitat refuge. Dens offer shelter from the elements and facilitate escape from predators, especially Coyotes (*Canis latrans*), in an environment that offers little natural cover (Egoscue 1979; Rongstad et al.1989; Herrero et al. 1991; Pruss 1999). Kitchen et al. (1999) found all Coyote-killed Swift Foxes near the periphery or outside their home range boundary, a significant distance from their nearest currently used den.

Thus, knowledge of habitat requirements for den sites might be an important component of Swift Fox conservation efforts (Hillman and Sharps 1978; Pruss 1999); however, results of studies on Swift Fox den site selection have varied. Swift Foxes may modify burrows dug by other animals such as American Badgers (*Taxidea taxus*), ground squirrels (*Spermophilus* spp.) or Black-tailed Prairie Dogs (*Cynomys ludovicianus*), or dig their own dens (Kilgore 1969; Hillman and Sharps 1978; Cameron 1984; Pruss 1999). Dens have been found in a variety of habitat types including short- and mid-grass prairie, grazed prairie, cultivated fields, fence rows, and rock outcrops (Cutter 1958; Hines 1980; Cameron 1984; Uresk and Sharps 1986; Rongstad et al. 1989; Pruss 1999). Occasionally, dens have been associated with man-made structures such as culverts, buildings, and cemetery gravesites with a concrete cap (Kilgore 1969; Hillman and Sharps 1978; Jackson and Choate 2000). Dens are frequently locat-

ed on or near tops of gently sloping hills, which are well drained and have a clear line of sight (Hillman and Sharps 1978; Cameron 1984; Uresk and Sharps 1986; Pruss 1999; Harrison 2003). However, dens also have been found in level, open areas and at the base of hills (Kilgore 1969; Hines 1980; Cameron 1984).

Den entrance characteristics vary among seasons and individual dens. There are indications that natal dens typically have more entrances than non-natal dens (Kilgore 1969; Hillman and Sharps 1978). Hines (1980) reported that Swift Foxes seem to select for entrances with west and east exposures. Similarly, Uresk and Sharps (1986) documented a trend toward dens with easterly exposures. In contrast, Rongstad et al. (1989) and Pruss (1999) found entrance exposure to be random.

An additional factor that might influence the selection of dens is the position of the site within the home range. Previous studies investigating den use in Swift Foxes have not considered den placement within the range as a factor influencing selection. We contend, however, that due to the importance of dens for predator escape (Herrero et al. 1991; Kitchen et al. 1999; Pruss 1999), placement relative to the home range core and boundary areas might be a driving force in selection. It is likely den placement is correlated to overall space use patterns and dens are positioned to facilitate a quick escape from an approaching predator.

The objective of this study was to determine the factors affecting den site selection for Swift Foxes on the Pinon Canyon Maneuver Site, in southeastern Colorado. We examined den site placement and microhabitat characteristics of active Swift Fox dens and compared these to sites not used by Swift Foxes.

Methods

Study Area

We conducted the study on the 1040-km^2 Pinon Canyon Maneuver Site (PCMS) in Las Animas County, Colorado. The dominant cover type on the PCMS is native grassland (60%), with Juniper (*Juniperus monosperma*) and Pinyon Pine (*Pinus edulis*) communities found in the hills and canyons (Shaw et al. 1989). Annual precipitation ranges from 26 to 38 cm (United States Department of Army 1980). Mean monthly temperatures range from –1°C in January to 23°C in July (Andersen and Rosenlund 1991). Predators known to kill Swift Fox are Coyotes (Covell 1992; Kitchen et al. 1999) and raptors (Covell and Rongstad 1990).

Swift Fox Capture

Swift Foxes were captured with double-door box traps (80 × 25 × 25 cm) baited with chicken or mackerel (Covell 1992). We deployed traps in the evening and checked them the following morning. Traps were not activated during periods when nighttime temperatures dropped below -10°C. We attached a radiocollar and ear tag to the Swift Fox and recorded the weight, sex and approximate age (using tooth wear) of the animal (Rongstad et al. 1989). All Swift Foxes were released at the site of capture. We followed telemetry procedures recommended by White and Garrott (1990). Locations were obtained by triangulating 2-3 bearings to the animal's position within a 10-minute period. Triangulation angles were maintained between 20° and 160° (Gese et al. 1988). We used aerial telemetry (Mech 1983) to locate missing animals. Telemetry error was determined by comparing telemetry locations with actual locations of stationary reference transmitters. When Swift Foxes were located in a den, we recorded the UTM coordinates of the den. We attempted to locate Swift Foxes approximately every 1-3 days with locations obtained throughout the 24-h period to reduce bias in home range estimates (used for den placement analysis).

Den Site Characteristics

Microhabitat characteristics of den sites were measured at a randomly selected sub-sample of the known active dens used by Swift Foxes during the breeding season (defined on the basis of energetic demands due to climatic changes and prey abundance, and behavioral characteristics to be 15 December to 14 April). Active dens were found by tracking radio-collared Swift Foxes. Den site selection was not stratified by sex as Swift Foxes form pair bonds with males and females concurrently using the same dens.

The following physical characteristics were measured at each den site: number of entrances, height and width of each entrance, den aspect, den position on hills, slope of site, percent rock in soil, vegetative cover, and horizontal foliar density. These characteristics were selected based on field observations and published descriptions of potentially important habitat characteristics (Hines 1980; Cameron 1984; Ursek and Sharps 1986; Rongstad et al. 1989; Covell 1992; Pruss 1999).

Den position on a hill was classified as bottom, middle, top, or flat when there was no hill. We determined maximum slope outside the den using a hand-held clinometer (Hays et al. 1981). The percentage of rock in the soil was visually estimated from the presence of rock in the dirt mound runway leading to the den entrance. Vegetation cover was determined by estimating the percent cover of grasses, forbs, shrubs, and bare soil in eight 1-m^2 plots randomly located within 10 m of the den. Percent soil and vegetation cover were estimated within the nearest 5% category. We indexed horizontal foliar density at 5 distances (10, 20, 30, 40, and 50 m) from the den in the four cardinal directions with a vegetation profile board and techniques for the fixed distance approach (Hays et al. 1981). The number of squares visible on a vertical board was counted by an observer lying down to approximate the visibility from the height of a Swift Fox.

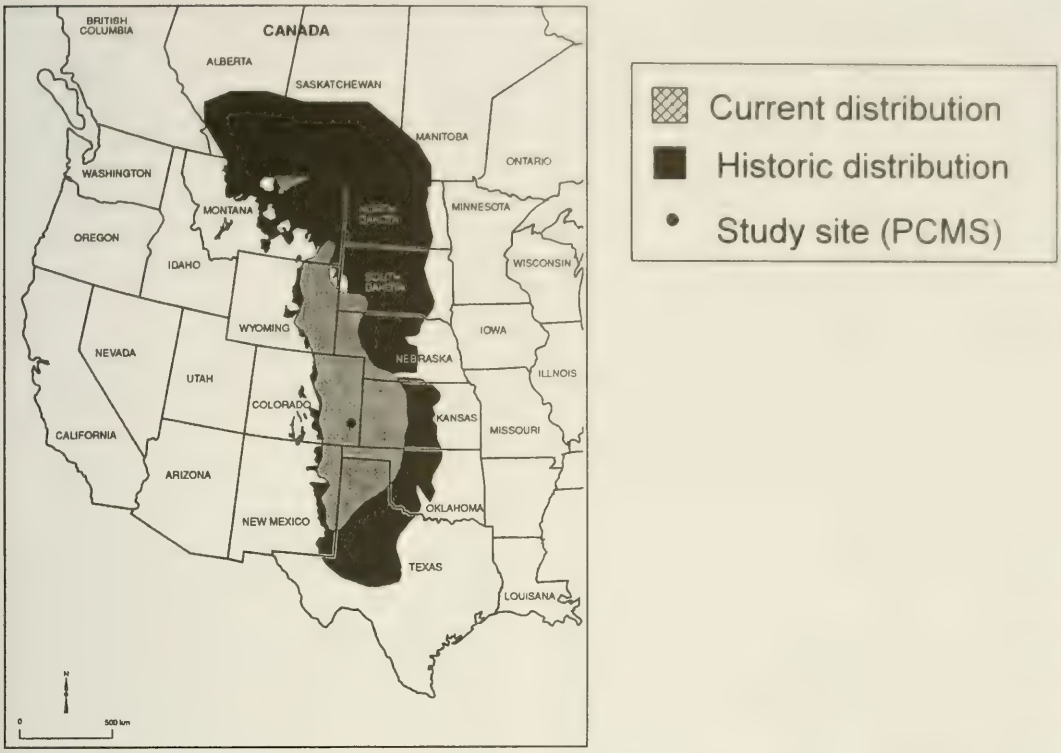

FIGURE 1. Swift Fox current and historic range and study area, Pinon Canyon Maneuver Site, Colorado, 2000.

Den Site Selection

To examine den site selection, we compared microhabitat characteristics of dens to control sites that represented available sites (Taylor et al. 1999). For each of the active den sites, we randomly selected one control site (not a den) within the Swift Foxes home range. We used the control site to compare the site characteristics of active den sites versus random sites within the Swift Foxes' home range. The control site was located 500 m away from the active den site in a random direction. This distance was arbitrary but allowed for selection of a random location within the home range. Because control sites were in the home range of the Swift Fox inhabiting the active den site, they were considered available as a possible denning location to the Swift Fox. The same den site characteristics were evaluated on the control sites, excluding variables associated with den entrances.

Den Placement

Dens used by Swift Foxes during the breeding season were recorded using telemetry procedures to assess the placement and use of the dens within the home range. The Swift Foxes' home ranges were described using a 95 % fixed kernel home-range estimator based on > 30 locations recorded within the breeding season (Worton 1989) with Arcview 3.0 software (Environmental Systems Research Institute, Inc., Redlands, California). Areas within the home range were then defined as the core area, which was the area within the 50% isopleth, the mid-range area, between the 50% and 75% isopleths, and the boundary area, between the 75% and the 95% isopleths. The number of dens and the frequency of use of those dens in the core, mid-range, and boundary areas of the home range were compared. In addition, we compared the number of dens in each area to the number expected from the proportion of each area in the home range; i.e., 50% within the core area, 25% within the mid-range area, and 20% within the boundary area.

Statistical Analysis

Because the habitat measurements were categorical, chi-square tests were used to assess the difference between habitat characteristics at active dens versus control sites (Zar 1999). Whether den entrances were randomly distributed around a circle (i.e., no predominant direction) was tested using Rayleigh's nonparametric Z test (Zar 1999). We attempted to predict class membership (i.e., active dens or control sites) by using a classification tree analysis with cost complexity pruning (CART: Verbyla 1987; S-Plus Version 6.0 1988-

2001.). Also called tree regression (Rejwan et al. 1999), this method repeatedly partitions the study sites into two groups (active dens and control sites) that are as similar as possible based upon the five variables common to both groups (position, slope, horizontal foliar density, percent rock in soil, and percent vegetative cover). Each of the independent variables is used at each step in the analysis regardless of whether they were previously used in the tree. The tree that is created is hierarchically structured with the complete data set at the top (the root) and the binary splits, referred to as "nodes", below to the final undivided "leaves" or groupings at the bottom of the tree. Analysis of variance with Tukey-adjusted post-hoc comparisons was used to assess the difference in the number of dens used and the number of times these dens were used by area (SAS Version 8.2 2001). Log transformations were used to achieve normality where deviations occurred. In cases where more than one den per Swift Fox was sampled, one den was randomly chosen for analysis to avoid pseudoreplication.

Results

Forty-two dens belonging to 42 Swift Foxes were located from December 1999 to April 2000 and used to evaluate den site characteristics. Most active dens had only one or two entrances and the maximum number of den entrances was seven. The mean height of den entrances was 19.4 ± 3.1 cm and the mean entrance width was 17.9 ± 2.5 cm. The percentage of dens with entrances oriented to the north, south, east, and west were 29.9, 21.1, 21.9, and 27.1%, respectively. These aspects were randomly distributed around a circle ($Z_{41} = 0.088$; $P = 0.54$), i.e., dens were not oriented in a predominant direction.

The mean maximum slope of active dens was 1.3 ± 1.3 degrees. We found no difference between the slope at den sites and control sites ($\chi^2 = 2.71$, df = 4, $P = 0.61$). Most dens (88.7%) and control sites (80.3%) were located on gentle slopes between 0 and 2 degrees. Four percent of control sites were located on slopes that exceeded 5 degrees, however, no dens were found on slopes that steep. The majority of Swift Fox dens were positioned either on flat ground or in the middle of a hill, and relatively few dens were located at the top or bottom of a hill (Figure 1). Control sites were found in similar positions with no detected difference between site position of used and control sites ($\chi^2 = 2.04$, df = 3, $P = 0.59$; Figure 1). We also found no difference in the pattern of visibility by distance from the den as compared to control sites ($\chi^2 = 0.06$, df = 4, $P = 0.99$). Visibility from both active den sites and control sites decreased uniformly in each direction as one moved away from the site. The vegetative cover of den sites and control dens was similar ($\chi^2 = 1.98$, df = 3, $P = 0.598$) with both dens and control sites occurring in areas mostly covered in grasses and soil (Figure 2). There was a significant difference in the percentage of rock at dens versus control sites ($\chi^2 = 8.91$, df = 3, $P = 0.03$; Figure 3) with dens having higher proportions of intermediate percentages of rock and control sites having higher proportions of rock below 5% or above 20%. The classification tree used to characterize the habitat at dens versus control sites failed to produce any biologically relevant pattern.

The average number of dens used per Swift Fox during the breeding season was 5.1 ± 2.1. The number of dens used by Swift Foxes varied by area of the home range ($F_{2,33} = 37.53$, $P < 0.001$; Figure 4a). Tukey's adjusted post-hoc tests indicated that more dens were used in the core area than in the mid-range and boundary areas (mid-range: $t_{33} = 6.29$, $P < 0.001$; boundary: $t_{33} = -7.54$, $P < 0.001$). There were also significantly more dens in the mid-range area than the boundary area ($t_{33} = -2.20$, $P = 0.035$). In addition, we found that the number of dens in each area varied from that expected from the proportion of the area, and thus the frequency of use of the area ($\chi^2 = 38.41$, df = 3, $P < 0.0001$).

Overall, there was a difference in the frequency of use of dens in the different areas of the home range ($F_{2,33} = 44.94$, $P < 0.001$; Figure 4b). The number of

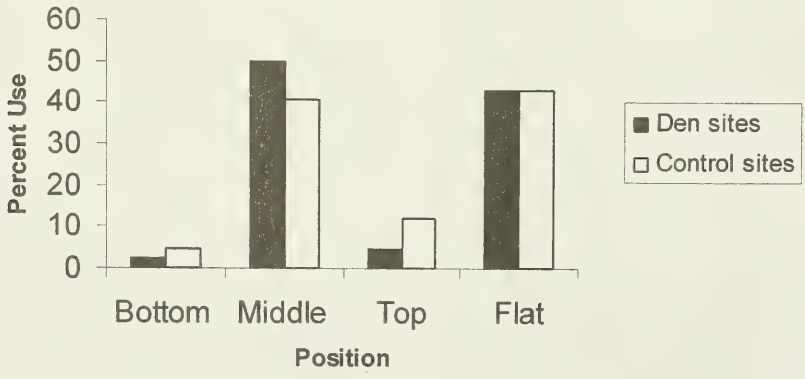

FIGURE 2. Position of Swift Fox den sites and control sites, Pinon Canyon Maneuver Site, Colorado, 2000.

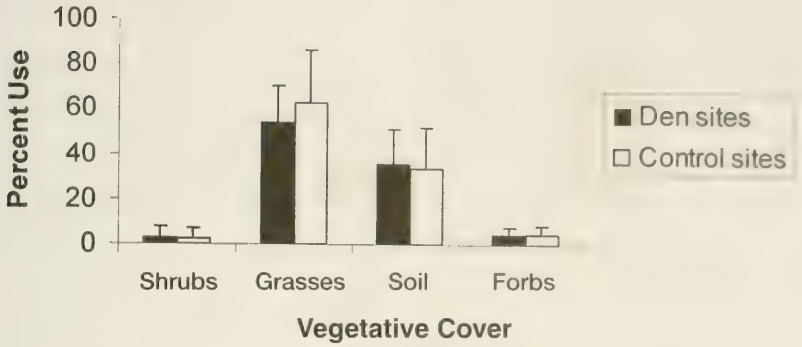

FIGURE 3. Vegetative cover at Swift Fox den sites and control sites, Pinon Canyon Maneuver Site, Colorado, 2000.

times that dens in the core area were used was higher than in the mid-range or boundary areas (mid-range: $t_{33} = 7.52, P < 0.001$; boundary: $t_{33} = 7.65, P < 0.001$). There was no difference in the number of times dens in the mid-range and boundary areas were used ($t_{33} = 1.55$, $P = 0.13$). The pattern of den use was variable. For example, one Swift Fox was located in only one den for a period spanning 67 days, while another Swift Fox used at least four different dens in a five-day period.

Discussion

Our results indicated Swift Foxes on the PCMS did not select den sites based on the microhabitat characteristics that we evaluated. However, Swift Foxes appeared to select areas of intermediate rock percentages. The selection of areas with intermediate rock percentages may be related to den structure and strength. Foxes had no preference for particular positions or vegetation at den sites despite other studies concluding that Swift Foxes preferentially selected den sites on hilltops (Uresk and Sharps 1986; Pruss 1999; Harrison 2003).

The finding that Swift Foxes in our study area select den sites with habitat characteristics that do not differ from control sites was not unexpected considering the homogeneous prairie environment on the PCMS. Our result does differ from other Swift Fox studies which reported preferences for certain habitat characteristics, however. The importance of selection of hill position and vegetation characteristics might be determined by variation in topography and habitat in the geographic area. Habitat selection by Swift Foxes on the PCMS appears to operate at the landscape level instead of at the den site level as Swift Foxes were only trapped on the open prairie on the PCMS despite efforts to capture Swift Foxes in wooded areas (Schauster et al. 2002).

Den site selection occurred at a larger scale; the placement of dens relative to areas within the home range was a significant factor in site selection. Foxes

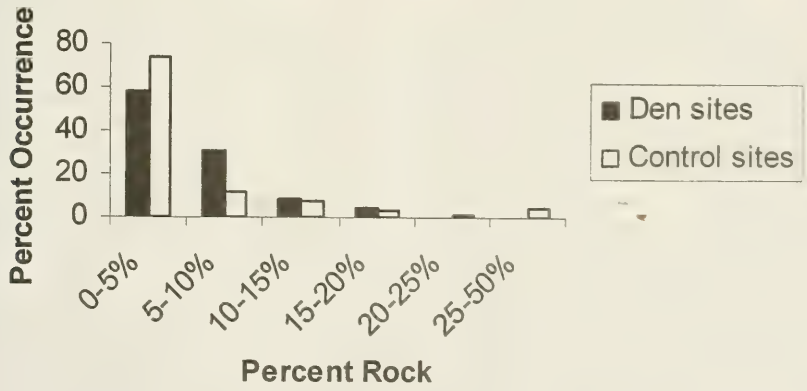

FIGURE 4. Percentage of rock at Swift Fox den sites and control sites, Pinon Canyon Maneuver Site, Colorado, 2000.

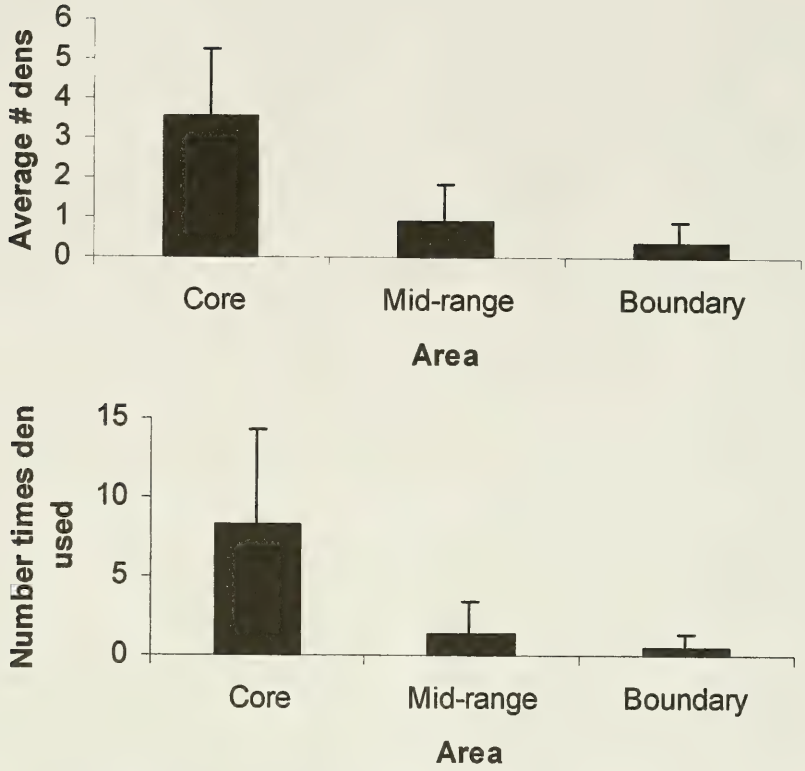

FIGURE 5. Placement of Swift Fox dens within the home range (top) and frequency of Swift Fox den use by area of the home range (bottom), Pinon Canyon Maneuver Site, Colorado, 2000.

used more dens in the core area of the home range as compared to the mid-range or boundary areas. In addition, dens in the core area were used more frequently by radio-tracked Swift Foxes than dens in the mid-range or boundary area. Den placement within the home range may be designed to facilitate escape from Coyotes. Previous studies have indicated that Swift Foxes use dens as a mechanism of escape from predators (Herrero et al. 1991; Kitchen et al. 1999; Pruss 1999) and that Coyote-caused mortality might be a key factor in limiting population growth in North America as well as the re-establishment of Swift Foxes on the Canadian prairies (Scott-Brown et al. 1987). Kitchen et al. (1999) found that all Coyote-caused Swift Fox mortalities occurred near or outside the Swift Fox's home range boundary, a substantial distance from their nearest currently used den.

Thus, Swift Foxes might maintain the majority of dens in the core area of the home range where they spend most of their diurnal hours (Schauster et al. 2002), and use dens only occasionally in the outer areas of their range to reduce encounters with and facilitate escape from predators. Previous studies have suggested that other preferences for den sites also might be due to Coyote avoidance, including den locations that are negatively associated with water sources (Pruss 1999), and dens that are closer to roads than unoccupied sites (Pruss 1994; Harrison 2003).

The importance of interspecific competition in determining den site selection has also been noted in Kit Foxes (List and Macdonald 2003) and Arctic Foxes (*Alopex lagopus*; Frafjord 2003). Frafjord (2003) documented that the distance to Red Fox (*Vulpes vulpes*) dens and the elevation from the tree line were the most important factors determining den use in Arctic Foxes. Kit Foxes in Mexico denned more often in grasslands and less in Prairie Dog (*Cynomys ludovicianus)* towns than expected (List and Macdonald 2003). These authors hypothesized that Kit Foxes reduced the amount of time they spent in Prairie Dog towns due to the activity of Coyotes.

Thus, Swift Fox den site selection in homogenous environments might be unrelated to microhabitat characteristics and more dependent on interspecific interactions and predator avoidance. This study also illustrates the importance of examining den site selection at multiple scales to determine all site selection factors. Due to the importance of denning to Swift Fox

ecology, a full understanding of den site selection in various environments is essential to recovery, reintroduction, and management efforts.

Acknowledgments

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First Records of the Northern Long-eared Bat, *Myotis septentrionalis*, in the Yukon Territory

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Jung, Thomas S., Brian G. Slough, David W. Nagorsen, Tanya A. Dewey, and Todd Powell. 2006. First record of the Northern Long-eared Bat, *Myotis septentrionalis*, in the Yukon Territory. Canadian Field-Naturalist 120(1): 39–42.

Three adult male Northern Long-eared Bats, *Myotis septentrionalis*, were captured in mist nets in July 2004 in the LaBiche River Valley, southeastern Yukon. These are the first records of *M. septentrionalis* in the Yukon. Further survey work is needed to delineate the extent of the range and population structure of this and other species of bats in northwestern North America.

Key Words: Northern Long-eared Bat, *Myotis septentrionalis*, distribution, Yukon.

The diversity and distribution of bats in northwestern North America (e.g., ≥55° N) is poorly documented. Few areas have been adequately surveyed, particularly for rare or cryptic species (*sensu* Nagorsen and Brigham 1993; van Zyll de Jong and Nagorsen 1994; Parker and Cook 1996; Parker et al. 1997). Youngman (1975) reported the Little Brown Bat (*Myotis lucifugus*) as the only species of bat in the Yukon. However, Youngman (1975) noted the possibility of other species occurring in the Yukon, such as the Big Brown Bat (*Eptesicus fuscus*) and Long-legged Bat (*Myotis volans*), based on single specimens collected near Fairbanks, Alaska, and Atlin, British Columbia, respectively. In the 30 years subsequent to Youngman (1975), no species of bats other than *M. lucifugus* have been confirmed from the Yukon. Slough (2000*), however, recorded a bat in southeastern Yukon that appeared to be a Big Brown Bat according to its echolocation call characteristics (C. Corben, personal communication), but it may have been a Silver-haired Bat (*Lasionycteris noctivagans*) and remains to be verified by a capture. We believe that species other than *M. lucifugus* may extend northward into the Yukon, and that a lack of records of other species is largely a function of previous search effort.

Based on a specimen collected in Nahanni National Park, Northwest Territories (van Zyll de Jong 1985), captures in recent surveys in adjacent British Columbia (Wilkinson et al. 1995*; Vonhof and Wilkinson 1997*), and an unidentified *Myotis* in a recording of an echolocation call (Slough 2000*), we suspected that the Northern Long-eared Bat (*Myotis septentrionalis*) and the Western Long-eared Bat (*Myotis evotis*) could be present in southeastern Yukon. In summer 2004, we undertook a preliminary field survey of the mammalian diversity in the boreal forest of southeastern Yukon, including a bat inventory. Here, we provide the first records of the Northern Long-eared Bat in the Yukon.

Methods

On 28 July – 2 August 2004, we used mist-nets to capture bats in the LaBiche River Valley (60.126°N, 124.064°W) of extreme southeastern Yukon. Mist-netting occurred at three sites; two sites were over small ponds (>150 m^2) within dense boreal forest, and another at an intersection of a roughly 3 m wide forest trail and a roughly 30 m wide forest access road. Nets were set across and bordering the ponds and perpendicular to the road and forest trail. Nets were opened 0.5 hr before sunset (about 23:00 hrs PDT) and closed 2–3 hr thereafter. A 6 m long mist net open for 1 hr was used as our definition of 1 mist-net hr.

Captured bats were examined for external diagnostic characteristics according to van Zyll de Jong (1985) and Nagorsen (2002), including presence of dark shoulder patches in the pelage, ear length, number of hairs on the trailing edge of the uropatagium, presence of keeled calcar, and relative length and shape of the tragus. We measured forearm length, ear length, and mass, and determined age as per van Zyll de Jong (1985). No voucher specimens were procured; rather, we obtained morphological measurements and wing punches for mitochondrial DNA sequencing to verify our field identifications. Wing punches were stored in 70% ethanol until lab analysis. Genetic analyses were conducted at the University of Michigan's Museum of Zoology (Ann Arbor, Michigan), and included an unweighted maximum parsimony analysis of 745 bp of the cytochrome *b* gene using 21 specimens of *Myotis* (Figure 1).

Results and Discussion

We amassed 42.1 mist-net hr over six nights of sampling; only six bats were captured. On 28 July 2004, we captured two adult male *M. septentrionalis* and one *M. lucifugus* at a small, shallow pond (ca. 108 m^2). On 29 July 2004, a third adult male northern *M. septentrionalis* and two *M. lucifugus* were captured at the same pond. Although three of our captures were consistent with the morphological traits of *M. septentrionalis* (Table 1), this species can be difficult to distinguish from other species of potentially sympatric long-eared *Myotis* (i.e., *M. evotis* and *M. keenii*), based on external characteristics alone (van Zyll de Jong 1979; Nagorsen 2002). DNA sequences, however, confirmed our tentative species identifications: the three *M. septentrionalis* are included in the *M. septentrionalis* clade (Figure 1).

The presence of *M. septentrionalis* in the Yukon is not surprising, considering that captures were reported from elsewhere in the Liard River Watershed by Wilkinson et al. (1995*), Bradbury et al. (1997*) and Vonhof and Wilkinson (1997*). The only voucher taken in those surveys to confirm identification, however, was a specimen of *M. septentrionalis* collected by Vonhof and Wilkinson (1997*) from the Fort Nelson River, British Columbia, near Highway 77 (Royal British Columbia Museum, RBCM 19516), about 140 km southeast of our captures. It is not known if there are breeding populations of *M. septentrionalis* in the Yukon, as no juveniles, or lactating or post-lactating females were captured. Breeding populations of the Northern Long-eared Bat, however, have been reported from nearby northeastern British Columbia (Wilkinson et al. 1995*, Vonhof and Wikinson 1997*). Similarly, it is not known if *M. septentrionalis* hibernates in the Yukon. No bat hibernacula have been found in the Yukon.

Despite low capture rates, we suspect that *M. septentrionalis* were locally common in our survey area, based on the number of captures relative to *M. lucifugus*. Moreover, we often detected what appeared to be *M. septentrionalis* at all of the mist-netting sites, based on low intensity echolocation calls (Faure et al. 1993) heard on narrowband bat detectors tuned to 40-50 kHz and observations of detection distances of passing bats. Our data, along with that of Wilkinson et al. (1995*), Bradbury et al. (1997*), and Vonhof and Wilkinson (1997*), suggest that *M. septentrionalis* may be locally common and widely distributed throughout the Liard River Watershed in British Columbia and the Yukon. We suspect that *M. septentrionalis* may occur throughout the Liard River Watershed in the Yukon, from the LaBiche River west to the Little Rancheria River. Other species of bats (e.g., *M. evotis*, *M. volans*, *Eptesicus fuscus*, and *Lasionycteris noctivagans*) may also be present in southern Yukon, but not yet confirmed with a capture, voucher, or DNA sample.

Perhaps the most intriguing question is whether *M. septentrionalis* is a long-established member of the Yukon mammalian fauna that has simply gone undetected, or, alternatively, is it a species that has recently (i.e. <100 years ago) colonized southeastern Yukon? Other mammals have recently colonized the Yukon, from the south, including: Mule Deer and White-tailed Deer (*Odocoileus hemionus* and *O. virginianus*; Hoefs 2001), Coyote (*Canis latrans*; Youngman 1975), and Cougar (*Puma concolor*; Jung et al. 2005). Moreover, Humphries et al. (2002) provided data from simulation models that suggested that the range of *M. lucifugus*, and presumably other species of bats in the boreal forest, would substantially move northward in response to global warming. Regardless of the origin of *M. septentrionalis* in the Yukon, these records underscore that our knowledge of the diversity and distribution, and population structure of bats in the Yukon is limited. Directed surveys are needed to address these information gaps and provide a basis for management and conservation initiatives that include bats.

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TABLE 1. Age, sex, and morphometrics of *Myotis septentrionalis* ($n = 3$) captured in the LaBiche River valley, southeastern Yukon, 28-29 July 2004.

Specimen Label	GenBank Accession	Species[1]	Sex	Age	Forearm Length (mm)	Ear Length (mm)	Mass (g)
LaBiche-1	AY883902	*M. septentrionalis*	Male	Adult	16	37.7	7.6
LaBiche-3	AY883904	*M. septentrionalis*	Male	Adult	15	35.8	6.6
LaBiche-9	AY883905	*M. septentrionalis*	Male	Adult	14	37.6	6.9

[1] As tentatively identified in the field and subsequently confirmed with genetic analyses.

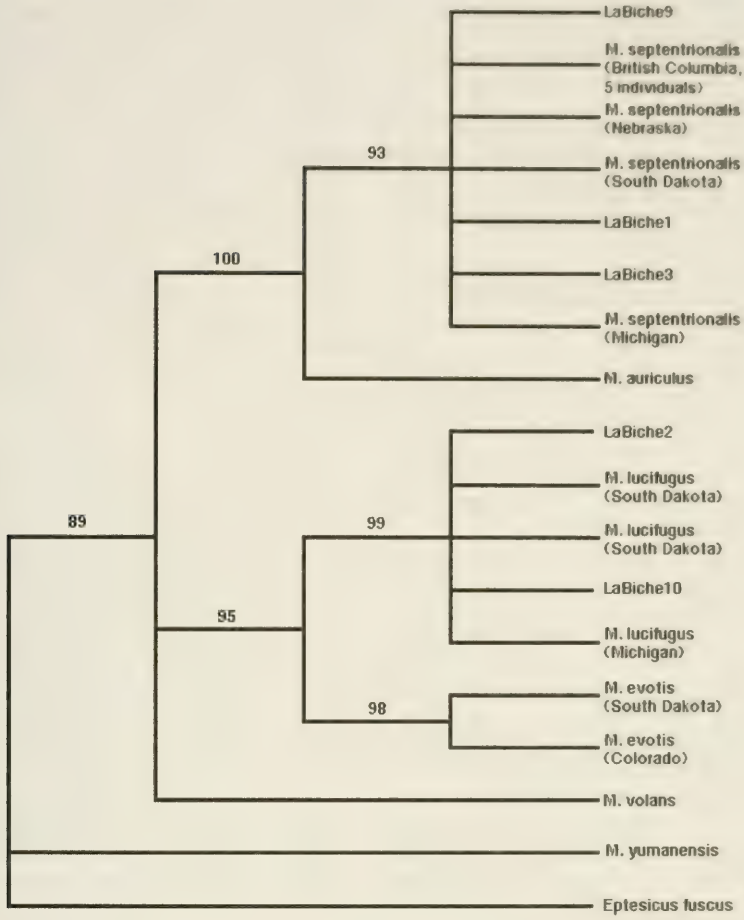

FIGURE 1. Placement of *Myotis septentrionalis* (LaBiche 1, 3, and 9) and *M. lucifugus* (LaBiche 2 and 10) samples collected in the LaBiche River Valley, Yukon, based on an unweighted maximum parsimony analysis of cytochrome *b* (745 bp) for these samples compared to other *Myotis*. *Eptesicus fuscus* is used as an outgroup. Numbers above the branches represent bootstrap support values for those nodes.

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Recent Declines of House Sparrows, *Passer domesticus*, in Canada's Maritime Provinces

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Erskine, Anthony J. 2006. Recent declines of House Sparrows, *Passer domesticus*, in Canada's Maritime Provinces. Canadian Field-Naturalist 120(1): 43–49.

House Sparrows, *Passer domesticus*, were introduced to North America after 1850, increased and spread up to 1920, and stabilized or decreased thereafter until 1960. In the Maritimes (and perhaps some other areas), a further decline set in after 1970, continuing to the present. Now the species is rare to absent in much of the Maritimes, except around farms with livestock. Decline here since 1970 probably approaches 90 per cent in most other areas of human settlement except south of 45° N. Similar declines are known in the U.K., but seem poorly documented, if recognized, in North America outside of our region.

Key Words: House Sparrows, *Passer domesticus*, declines, New Brunswick, Nova Scotia, Prince Edward Island

Fifty years ago, House Sparrows (*Passer domesticus*; HoSp hereafter – a standard abbreviation used in many reports of organized birding activities) were so nearly ubiquitous in and around human settlements in eastern Canada that one sometimes had to "tune them out" to hear other birds. Then, it would have been unimaginable that this abundant species could become scarce in our lifetimes. HoSp, and their (urban) habitats, were virtually beneath notice both of birders and academics, so few serious studies of the species were made (see Kendeigh 1973), and none in Canada, during the rapid expansion of research on birds after World War 2. The result is a continuing scarcity of hard data on HoSp, precluding rigorous discussion of its population ecology. This study is a first look at what happened in the recent past and what may still be investigated usefully, in the Maritime Provinces of Canada [New Brunswick, Nova Scotia, and Prince Edward Island (hereafter "the Maritimes")].

HoSp were first introduced to North America around 1850, and became established in the Maritimes by the 1880s (Christie 1979; Lowther and Cink 1992). Numbers and densities in the next century are known mainly from anecdotal remarks in general accounts. As was general in eastern North America by the early 20th Century, HoSp were nearly ubiquitous and very common around human settlements, including cities, towns, villages, and even isolated farms. HoSp thrived on grain wastage, as well as using other food wastes. Nearly all human settlements, through the 1940s, harboured domestic animals, especially livestock and poultry, which were fed on small grains at least seasonally.

Motor vehicles began replacing horses in transportation by the 1920s, and the resulting decrease in horse droppings and other waste grain sources led to a decline in HoSp, documented mainly by general statements (e.g., Bent 1958). Motor vehicle use in the Maritimes was much less during the Great Depression of 1930s, when most people could not afford cars, and in World War 2, when gasoline and tires were reserved for military use. Use of horses again became widespread in those decades, and that presumably slowed or halted the earlier decline of HoSp. After the war, motor vehicles again became available, use of horses declined rapidly, and probably HoSp also declined. Very few bird counts were made in the Maritimes before 1960, when HoSp still were considered widespread and abundant (Squires 1952; Godfrey 1954; Tufts 1962). Winter bird counts at Wolfville, Nova Scotia (J. S. Erskine 1968) showed no obvious trend in HoSp numbers between 1948 and 1968. Christie (1979) summarized bird status changes in the Maritimes over the century to 1978, noting arrival, increase, and subsequent decline in HoSp, with numbers likely stable after 1930.

Starting in 1977, winter plot counts through 1988 in Sackville, New Brunswick (Erskine 1992b), showed further decreases in HoSp – evidently *not* related to decline of horses and other livestock, which already were absent in such towns (compare Erskine and McManus 2005). Also in the 1980s, Christie (1985 and following years) remarked on generally lower HoSp numbers on New Brunswick Christmas Bird Counts (CBCs hereafter). Some naturalists (personal communications) remarked on similar decreases in Nova Scotia in the early 1990s. The cooperative Breeding Bird Survey (BBS) documented HoSp declines across eastern Canada in summers 1967-1996 (Downes and Collins 2003), with decreases each decade (significant only in 1981-1990) in the Bird Conservation Region (BCR 14) including the Maritimes. HoSp continued to decline, and by 2000 were rare in Sackville, New Brunswick (personal observations), and in nearby towns.

In the near-absence of even quasi-systematic counts of HoSp, CBCs provided the only widespread sampling of bird numbers in the Maritimes, with many more counts in more years than the BBS. Although CBC data are poorly standardized (e.g., Dunn et al. 2005), those surveys are extensive enough, both here and across

Canada, to allow examination of HoSp occurrence in various habitats, in an attempt to identify factors involved in their recent declines.

Methods

Christmas Bird Counts are single-day annual counts in the period 13 December to 5 January, each restricted to a 24-km diameter circle selected subjectively. Bird species richness and availability of observers are usual selection criteria.

CBC data for HoSp in the Maritimes in 1960-2003 were extracted from *N. B. Naturalist* (formerly *Nature News*), *Nova Scotia Birds* (formerly *N. S. Bird Society Newsletter*), and *Island Naturalist*. Audubon publications (*American Birds*, formerly *Audubon Field Notes*) included many fewer counts ("circles" hereafter) in the Maritimes, and were used only to fill gaps in regional publication series. All data were tabulated in year vs. location matrices.

Data were selected by excluding circles surveyed in <=20 years and others with obvious "discontinuities" in coverage or effort. The selected circles were grouped by major non-urban habitat combinations, most including also some human settlements, thus (names in parentheses used in text and tables hereafter):

- (**Forest**) inland, predominantly forested, little or no farming;
- (**Coastal**) much forest or bog, farming insignificant;
- (**Farm=forest**) inland or coastal, farms and other open areas minor or unproductive but roughly equal in area to forests;
- (**Farm>forest**) farming major (much exceeding forest), relatively productive, usually around a sizable town;
- (**Major urban**) cities or larger towns, other habitats minor.

To allow for varying observer effort, between years or circles, published counts ("raw data") were also converted to birds/10 party-hours ("adjusted data"; see also Discussion).

Statistics on area changes in major habitats of the Maritimes over the study period (roughly 1960-2000) were assembled from Statscan websites, Canada Year Books, and some other directories.

Extrapolation from CBC data to Maritimes HoSp populations was attempted. Counts from the selected circles were expanded across the five habitat groupings above. Further adjustment was made to cover two important omissions in coverage:

- not all suitable areas within active CBCs were surveyed, and
- not all HoSp in the areas surveyed were detected.

Those factors could not be assessed rigorously, but "informed guesses" from personal experience (see Appendix) allowed tentative adjustment of extrapolated estimates.

Results

HoSp counts (adjusted data) for each selected circle in the various habitat-groupings were summarized as decade-means (1960-69, 1970-79, etc.; Table 1). Circles lacking data for >1 decade were excluded, as were those lacking 1 decade and >=3 years in a 2nd decade. Mean data were estimated for circles missing one decade, using ratios of HoSp counts in other circles in that and the next decade(s). Some general patterns were evident:

(i) a HoSp decline (from an earlier "plateau"), most often starting in the 1980s, was apparent nearly everywhere, in all habitats, and whether raw or adjusted data were compared;

(ii) the recent decline was less pronounced in circles where farmlands were important, or at least equal in area to forests, than elsewhere;

(iii) the recent decline began earlier in cities and large towns than elsewhere.

Observer effort in and around cities and towns in 1960-1979 increased so much that increased detection of HoSp then sometimes balanced or exceeded declines, which were less apparent in raw data vs. adjusted data.

Area changes in major habitats were substantial, as follows:

(a) Forests remained the largest land cover type in New Brunswick and Nova Scotia throughout; forest cover increased in Prince Edward Island, but that was minor in the overall picture. HoSp were never found in or near forests except in association with human settlements, so changes in forest area are ignored in further discussion.

(b) Among farmlands, "improved lands" (= crops, pasture, fallow; the main farmland types used by HoSp, aside from buildings) decreased in all provinces, by 35% in Prince Edward Island (where those remain dominant land-uses), and by 55% in New Brunswick and Nova Scotia, between 1961 and 1996. Published statistics available did not distinguish "commercial" and "marginal" farms; most decline in New Brunswick and Nova Scotia was in marginal farms, on which before 1960 farming was only one of several sources of income. Land-use on commercial farms became more intensive in 1961-1996 (personal observations), in the Maritimes as elsewhere, but that was not obvious from the published statistics.

(c) Urban area statistics allowed few generalizations. Larger communities mostly increased in human population and area, whereas many smaller ones decreased, some dwindling to scattered houses. Cultural changes within urban areas were many and widespread, involving sweeping changes in commerce, transportation, heating, garbage disposal, tolerance of livestock and poultry, recreation, etc. [see review in Erskine and McManus 2005]. Correlations with single factors in urban change could not be made rigorously so did not warrant statistical tests.

Table 1. Comparison of CBC HoSp means over decades, by habitats: (a) Raw data, (b) Adjusted data. Missing data added from ratios (of all groups) to next decade. Circles with no HoSp ever omitted.

(a) Raw data	1960-69	1970-79	1980-89	1990-99	2000-02
Forest areas					
7 circles	439	530	450	117	49
Coastal settlements, no farming					
11 circles	875	1306	1023	404	138
Farming & woodlands nearly equal					
11 circles	2120	2482	1823	949	735
Major farming areas, larger communities					
8 circles	3306	4596	4953	2695	1296
Cities					
4 circles	4017	3569	1664	374	157
Grand totals:	10757	12483	9913	4539	2375

(b) Adjusted data	1960-69	1970-79	1980-89	1990-99	2000-02
Forest areas					
7 circles	599	476	331	58	25
Coastal settlements, no farming					
11 circles	596	442	211	101	37
Farming & woodlands near equal					
11 circles	1255	927	672	216	160
Major farming areas, larger communities					
8 circles	2130	1840	1153	500	240
Cities					
4 circles	1568	1001	283	39	19
Grand totals:	6148	4686	2650	914	481

Extrapolated HoSp populations by decades, expanded from surveyed circles across suitable habitats, and adjusted for incomplete coverage and detection, are shown in Table 2.

That suggested that since the 1970s total HoSp numbers in the Maritimes decreased greatly, probably by three-quarters or more, with urban numbers – in New Brunswick and Prince Edward Island – diminishing to less than 10% of levels prevailing before 1980. Farmland HoSp numbers still may be one-half to two-thirds of those present 30-40 years earlier – more likely less. They now account for the vast majority of all HoSp remaining in New Brunswick, Prince Edward Island, and northern and eastern parts of Nova Scotia, where winter conditions and especially snow cover limit survival at that season. Numbers in western and southern Nova Scotia declined to a lesser degree.

Discussion

Johnston and Klitz (pages 15-52 *in* Pinowski and Kendeigh 1977) stated "The house sparrow seems clearly a product of interaction between sparrows and sedentary, agricultural man... This is a long-term relationship, sufficient to allow fine-grain adaptation of the birds to man's way." There seems no reason to dispute that generalization, on the long-term, broad-scale stage for which it was stated, but regional evidence suggested that "man's way" in the Maritimes recently changed more rapidly than did HoSp adaptations to it.

Generalization from CBC data. Rigorous conclusions regarding the recent HoSp decline in the Maritimes (or elsewhere) will not emerge from CBCs alone, but improved understanding may result when various kinds of information are combined. The scarcity of hard data on this species, anywhere in North America, is embarrassing. In the Maritimes and adjacent regions, the only multi-year study found that provided HoSp density indices directly was the one in Sackville, New Brunswick (Erskine 1992b) that stimulated this investigation. Knowledge of habitats and diet here relied on casual observations, as no planned studies had been made – and HoSp numbers in most areas now are too low for economical study.

CBC data are poorly standardized, and adjusting effort using party-hours addressed only a small part of variation in CBC data (compare Dunn et al. 2005). Regional data have not been examined rigorously, but it was obvious that the few – mostly urban – circles deploying large numbers of observers detected far fewer HoSp relative to effort than were found on most counts with fewer observers. Thus, declines in large urban areas may have been less drastic than indicated by the counts adjusted by party-hours, but they were impressive: compare means of raw data for 1966-1970 vs.

Table 2. Expansion of counts in Table 1 (raw data) to total Maritimes population estimates (explanation in Appendix).

Habitats	Extrapolated estimates				
	1960s	1970s	1980s	1990s	2000s
Forest+urban	1694	2045	1735	452	189
Coastal+urban	16944	25290	19809	7824	2673
(Farm=forest)+urban	55506	64980	47730	24846	19242
(Farm>forest)+urban	78520	109160	117630	64010	30780
Large urban	120510	107070	49920	11220	4710
farming	67013	87070	115752	71085	45020
urban	206161	221475	121072	37267	12574
Grand totals:	273174	308545	236824	108352	57594

1996-2000 at Fredericton (3379 vs. 53), Moncton (1046 vs. 142), Saint John (501 vs. 74).

Also, CBC data often were less adequate for HoSp than for most other bird species. When HoSp were abundant and ubiquitous in urban areas, some CBCs did not actually count them during the "census", merely inserting round-number estimates as reported totals. Where such obvious guesses recurred in several years, those counts were excluded. A more frequent problem was that parts of many urban areas, where HoSp were the most expectable birds, were ignored as unproductive (of more interesting species!) until HoSp decline was far advanced.

HoSp declines in urban areas. That the recent HoSp decline in the Maritimes began earlier in cities (except perhaps 'Greater Halifax') than less urbanized situations suggested that influences formerly encouraging HoSp to associate with human settlements are now less strong. Changes since 1960 in the regional urban milieu that might have been expected to affect HoSp numbers included:

Favourable influences

(i) winter bird-feeding increased greatly since 1960; however, small grains – preferred by HoSp (Bent 1958, also personal observations) – are now much less often presented (Rutherford 1984), feeding stations now offering mostly sunflower and thistle seeds, rather than oats, cracked corn, or "chicken scratch feed" mixtures;

(ii) shelter in urban hedges and other shrubs increased, presumably in response to increased disposable income of home-owners;

Negative influences

(a) food from human garbage, livestock wastage and manure decreased greatly, by disappearance of livestock, especially horses, and improved garbage disposal, these factors all related to increasing "urbanization";

(b) nesting and wintering shelter within buildings decreased, through removal of dilapidated structures and renovation of others – especially closing of openings (personal observations);

(c) transmittal of pathogens (e.g. *Salmonella*) may have been aided by increased transportation between urban areas (Erskine 1980b; a HoSp die-off at Charlottetown, Prince Edward Island, had been reported in the preceding winter);

(d) avian predators in towns (especially Merlin, *Falco columbarius,* and Sharp-shinned Hawk, *Accipiter striatus*) increased, with Merlins breeding in urban areas here since the 1980s; domestic cats, *Felis catus,* also increased.

The recent major decline of urban HoSp in the Maritimes indicated that urban areas no longer provide a favourable environment for this species, in winter or summer or both. Complete disappearance of HoSp in winter in many smaller human settlements suggested a "threshold effect"; below some population level, which likely varies with winter severity and availability of suitable habitats nearby, production in urban HoSp may no longer balance winter losses in this resident species.

HoSp declines in farmlands. HoSp decline in farming areas seemed better correlated with decreases in farms with livestock than with total numbers of farms or areas of "improved farmland". Loss of invertebrate food through pesticide use, as in England (D. Summers-Smith, letter), seems plausible but is unstudied here; chemical treatments in regional agriculture are obvious especially in potato- and fruit-producing areas, less so in grain production (mostly oats). Much Maritimes farmland area is inaccessible to HoSp in winter owing to snow cover. Livestock disappeared completely from most urban areas, and also from many former farms now used as rural residences or "hobby farms". Horses are scarce generally, and cattle now are mostly found in large feed-lot operations, where larger birds (gulls, pigeons, corvids, starlings) often out-compete HoSp – though a few of the latter persist (personal observations). Concentrations of HoSp persist in productive farming areas, even when disappearing from nearby towns, presumably because livestock operations now are mainly in better farming areas.

From the viewpoint of agriculture (and general economy), the Maritimes are a "backwater". Agriculture here ranks far behind forestry, tourism, fisheries, and "gen-

eral service" on economic and employment indices, despite the local importance of potatoes and orchards. Snow cover and related temperatures are major factors limiting agriculture (and HoSp) here. Soils and geology underlie the picture, with limestone areas very limited. Agricultural changes since World War II involved abandonment of former marginal agricultural lands rather than intensified use of better farmlands.

HoSp responses to habitat changes. All CBC habitat groupings used herein involved combinations of human settlements, of varying size, with nearby habitats, among which only farmlands were regularly used by HoSp. Human settlements formerly provided HoSp with both sheltered nesting places and nearby feeding opportunities. After nesting, urban HoSp often withdrew from built-up areas to glean waste grain in agricultural lands within a radius of 2-3 km, returning to towns and villages with the approach of winter (personal observations; Summers-Smith 1963). Where little farmland exists near urban settlements, in forested regions (e.g., Miramichi, New Brunswick) or within larger cities, urban HoSp presumably depended year-round on feeding opportunities within the city.

Cultural changes altered urban areas more, as well as in different ways, than farmlands. Thus, HoSp in areas that combined extensive farming with urban settlements were (and are) less restricted for feeding than those relying year-round on urban areas. Recent trends suggest that HoSp might disappear within a few decades from most urban habitats in New Brunswick and Prince Edward Island, where snow-cover limits their use of non-urban habitats in winter. They may persist longer in "Greater Halifax", and in some towns in farming areas of western Nova Scotia, where snow cover is less and winter temperatures more moderate. Such changes presuppose continuation of climates similar to recent decades; if "global warming" brings markedly less snow here, numbers of a winter-limited species – as HoSp appears to be – might again increase.

Estimating HoSp populations. Extrapolating observed numbers across potential HoSp habitat to regional populations (Table 2) involved much "informed guesswork", as hard data do not exist for most needed adjustments. Valuable perspective may emerge from such simple "modeling", even though it lacks rigour and precision.

Modeling allowed comparison with the only other independent estimate of Maritimes HoSp populations, derived from abundance indices in the Maritimes breeding bird atlas (Erskine 1992a) in 1986-1990. The Atlas estimates used a general algorithm (C. Field and P. Payzant, Appendix D *in* Erskine 1992a) for extrapolation to areas unsampled or lacking abundance indices; that algorithm may not have been fully appropriate for HoSp, of which density varied greatly between habitats. The Atlas estimate of HoSp (140 000 pairs) was of a similar order to that for the same period (1980s) in Table 2 (ca. 240 000 individuals).

The HoSp situation elsewhere. No systematic studies of HoSp were available in other parts of Canada. CBC data there – tabulated and adjusted for party-hours as in the Maritimes (unpublished MSS) – revealed no such drastic HoSp declines as seen here in 1960-2003.

Continuing availability of small grains in both rural and urban areas of the Prairie Provinces south of the boreal forest were well-correlated with the highest HoSp CBC counts on the continent, with no suggestion of declines unrelated to count efforts. British Columbia CBC data were extremely variable, with generally low numbers, as was to be expected from the varied geography and relative scarcity of arable farming. No long-run counts suggested continuing declines in HoSp there. Very few long-run counts were available in northern, deep-snow areas of western Canada, where most showed no HoSp at any time.

Quebec experiences the largest average snowfalls in Canada outside the western mountains. Most of the few long-run (>20 years) CBCs in Quebec suggested some decline in recent decades, from "adjusted counts", as reported also from independent surveys (1970-1991) by Cyr et Larivée (1995); those declines were less extreme than in the Maritimes.

In Ontario, where CBCs are more numerous than elsewhere in Canada, HoSp (raw) numbers remained generally stable over the decades, except in a few long-run urban circles near the northern limits of human settlement. Adjusted data, however, suggested declines, starting in 1980s, on nearly half the long-run counts; Sudbury showed the largest proportional decline, and counts at Sault Ste. Marie and Thunder Bay, also northern areas with much snow cover — and despite both being ports involved in grain shipping from the Prairies, also declined.

In the United Kingdom, where the HoSp situation has been followed for decades, especially by Denis Summers-Smith (1963, 2003, and letters), declines evidently are of a similar order to those found in the Maritimes. Although research on HoSp is limited there too, much detailed information is available on habitat relations of HoSp in the U.K. Summers-Smith's conclusions (op. cit.) regarding causation agree well with tentative inferences suggested here for the Maritimes – despite the near-absence of snow cover as a limiting factor in the U.K. The intensity of agriculture there is much more comparable to that in southern Ontario or the Prairie Provinces than to the Maritimes. At this time it seems likely that many different factors, some general and widespread, others applying only regionally, are involved in recent declines of HoSp in the wider picture.

A recent discussion of HoSp decline in North America (Holder 2003) drew on wide-ranging surveys, including BBS and CBC, but reached few con-

clusions except that competition with recent House Finch populations had not affected HoSp numbers. Use by Holder of only CBCs reported to Audubon limited his understanding of the Maritimes situation. His expressed suggestion (page 65) that the HoSp situation in Canada might parallel that in the U.K. – where very different climatic and economic regimes prevail – seems unlikely.

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Appendix

(i) Factors, by habitat groupings, for expansion from long-run CBC circles to total areas in Maritimes. Note: Forest areas support very few or no HoSp, so those areas were ignored, except where CBCs had been done.

Habitats	Number long-run CBC circles		Potential CBC circles + other potential habitat
Forest + urban	7	add	8
Coastal + urban	11	add	60
(Farm = forest) + urban	11	add	37
(Farm > forest) + urban	8	add	11
Large urban	4	add	4

(ii) Expansion factors, by habitat groupings, for incomplete coverage of suitable habitats in circles and incomplete detection of HoSp in areas covered.

Habitats	Coverage	Detection
Forest + urban	1.2	1.5
Coastal + urban	2.0	1.5
(Farm = forest) + urban	3.0	2.0
(Farm > forest) + urban	5.0	2.0
Large urban	5.0	3.0

(iii) Segregation of HoSp numbers among habitats, where appropriate. Forest and coastal habitats omitted as not used by HoSp; thus only 3rd & 4th categories above required segregation, with proportions varying over time.

Decades	1960s	1970s	1980s	1990s	2000s
Farm:urban ratio	50:50	50:50	70:30	80:20	90:10

First Record of the Southern Red-Backed Vole, *Clethrionomys gapperi*, in Newfoundland: Implications for the Endangered Newfoundland Marten, *Martes americana atrata*

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We report on the first capture of the Southern Red-backed Vole (*Clethrionomys gapperi)*, the eleventh non-native terrestrial mammal established on the island of Newfoundland over the last 150 years. Red-backed Voles may have been accidentally introduced by unknown sources in pulpwood imports or may have been deliberately introduced in an attempt to augment the depauperate small mammal fauna as a vigilante recovery effort for the endangered Newfoundland Marten (*Martes americana atrata)*. We anticipate significant utilization of the Red-backed Vole as prey by both Newfoundland Marten and Red Fox (*Vulpes vulpes*) with associated demographic responses within and between these species. Red-backed Voles will likely change habitat utilization patterns for the endemic subspecies of Meadow Vole, *Microtus pennsylvanicus terraenovae*.

Key Words: Southern Red-backed Vole, *Clethrionomys gapperi*, Marten, *Martes americana atra*, introduced species, Newfoundland.

The island of Newfoundland has only 13 resident native species of terrestrial mammals (Bangs 1913; Cameron 1958; Dodds 1983; Table 1). A fourteenth species, the Newfoundland Wolf (*Canis lupus beothucus*) was extinct by the early 20th century (Allen and Barbour 1937), and one of the three native mustelids, the Newfoundland Marten (*Martes americana atrata*) is currently listed by the Committee on the Status of Endangered Wildlife in Canada as endangered (Lemon 1996*). As well, the indigenous community of terrestrial mammals in Newfoundland has a skewed composition, with a disproportionate number of predators and few prey species; historically, only one microtine, the native subspecies of Meadow Vole (*Microtus pennsylvanicus terraenovae)* occurred on the island (Dodds 1983). Moreover, Cameron (1958) considered 10 of the 14 native species of terrestrial mammals as endemic subspecies; recent genetic analysis has confirmed the subspecies classification of the Newfoundland Marten (Kyle and Strobeck 2003). However, over the last 150 years, an additional nine species of mammals have been either intentionally or accidentally introduced to the island (Dodds 1983; Gould and Pruitt 1969; Northcott 1974*; Northcott et al. 1974; Payne 1976; Table 1). A tenth species, the Eastern Coyote (*Canis latrans*) became established on the island of Newfoundland in 1985, likely after crossing on sea ice from mainland Nova Scotia (Parker 1995). Herein, we report the first record of the eleventh non-native mammal established on the island of Newfoundland, the Southern Red-backed Vole (*Clethrionomys gapperi),* and discuss the circumstances and implications of this recent introduction, particularly with reference to the Newfoundland Marten.

Field Sites and Sampling

Between 2 and 5 November 1999, as part of a larger study investigating the demography and ecology of the Newfoundland Marten, we indexed small mammal populations on four sites inside the Pine Marten Study Area (PMSA) in southwestern Newfoundland (48°37'N, 57°53'W). The PMSA is a 2078-km^2 wildlife reserve, that was created in 1973 by the Newfoundland and Labrador Wildlife Division, for the protection of the Newfoundland Marten (Snyder and Bissonette 1987). Sites 1–3 were overmature (81+ years), Balsam Fir (*Abies balsamea)* stands, whereas Site 4 was a regenerating (10–15 yrs) Balsam Fir stand that regenerated after an outbreak of Spruce Budworm (*Choristoneura fumiferana*) and Hemlock Looper (*Lambdina fiscellaria fiscellaria*) in 1987. Site 4 contained a mix of young Balsam Fir and early successional species, such as White Birch (*Betula papyrifera*) and Pin Cherry (*Prunus pensylvanica*), had a significant number of dead Balsam Fir snags, and had no canopy. Each site was trapped with 100 snap traps on 3 consecutive nights. Traps were baited with peanut butter, and placed in pairs at 50 trapping stations, spaced 15 m apart, yielding a 735-m transect, following the methods previously used by Thompson and Curran (1995). All captures were recorded and collected for further analysis.

Forty small mammals were collected on the four sites over 1200 trap nights: 8 Meadow Voles, three Deer Mice (*Peromyscus maniculatus*), 10 Masked Shrews (*Sorex cinereus*), and 19 Southern Red-backed Voles. How-

TABLE 1. Native and non-native[1] terrestrial mammals on the island of Newfoundland prior to the discovery of the Southern Red-backed Vole[1].

Order	Family	Scientific Name (Authority)	Common Name
Insectivora	Soricidae	*Sorex cinereus acadicus* (Gilpin)	Masked Shrew *
Chiroptera	Vespertilionidae	*Myotis lucifugus lucifugus* (Le Conte)	Little Brown Bat
		Myotis septentrionalis (van Zyll de Jong)	Northern Long-eared Bat
Lagomorpha	Leporidae	*Lepus arcticus bangsii* (Rhoads)	Arctic Hare
		Lepus americanus struthopus (Bangs)	Snowshoe Hare *
Rodentia	Cricetidae	*Microtus pennsylvanicus terraenovae* (Bangs)	Meadow Vole
		Peromyscus maniculatus (Wagner)	Deer Mouse *
		Ondatra zibethicus obscurus (Bangs)	Muskrat
	Scuridae	*Tamiasciurus hudsonicus ungavensis* (Anderson)	Red Squirrel *
		Tamias striatus lysteri (Richardson)	Eastern Chipmunk *
	Castoridae	*Castor canadensis caecator* (Bangs)	Beaver
	Muridae	*Rattus norvegicus norvegicus* (Berkenhout)	Norway Rat *
		Mus musculus domesticus (Rutty)	House Mouse *
Carnivora	Mustelidae	*Mustela erminea richardsonii* (Bonaparte)	Short-tailed Weasel
		Mustela vison (Schreber)	Mink *
		Martes americana atrata (Bangs)	Newfoundland Marten[2]
		Lontra canadensis degener (Bangs)	Otter
	Felidae	*Lynx lynx susolanus* (Bangs)	Canada Lynx
	Canidae	*Vulpes vulpes deletrix* (Bangs)	Red Fox
		Canis lupus beothucus[3] (Allen and Barbour)	Eastern Timber Wolf
		Canis latrans var. (Lawrence and Bossert)	Eastern Coyote *
	Ursidae	*Ursus americanus hamiltoni* (Cameron)	American Black Bear
Arctiodactyla	Cervidae	*Rangifer tarandus terraenovae* (Gmelin)	Woodland Caribou
		Alces alces americana (Clinton)	Moose*

[1]Several other species are either seasonal visitors (e.g., Arctic Fox (*Alopex lagopus*), Polar Bears (*Ursus maritimus*)) or have been introduced to offshore islands (e.g., Bison (*Bison bison*), Bank Vole (*Clethrionomys glareolus suecicus*)). Adapted from Cameron (1958) and Dodds (1983).
[2]Subspecies designation confirmed via recent genetic analysis (Kyle and Strobeck 2003).
[3]Extinct

ever, Red-backed Voles were captured on only two of the four sites (Sites 3 and 4). The two sites where Red-backed Voles were captured were approximately 6 km apart, but on opposite sides of Little Grand Lake. Movement between these two sites would require an overland dispersal of at least 11 km, suggesting that the species is well established in the area. At least one of the collected females had obvious placental implantation scars on the uterine horns, indicating recent breeding. Species identification was confirmed by pelage and dental characteristics (Banfield 1974).

Discussion

Sites 1–3 had previously been snap trapped for small mammals for 4 years, between 1990 and 1993 (Thompson and Curran 1995). Additionally, Site 4, as well as the general area encompassing all four of our sampled sites, was extensively live trapped from 1993 to 1997, as part of a larger study investigating Marten, small mammal communities, and forest structure (Adair 2003). Neither of these two previous trapping efforts captured Red-backed Voles, suggesting that the species had recently become established, most likely sometime during or after 1998. Moreover, a more extensive small mammal survey, conducted two weeks before this survey in the Red Indian Lake area, approximately 35 km east of our four trapping sites, using identical methods but involving 16 sites and >4900 trap-nights, captured 116 small mammals, but no Red-backed Voles. Autumn (October) small-mammal surveys in the Red Indian Lake area, repeated annually since 1999, have subsequently documented the arrival (2001) and eastward dispersal of the Red-backed Vole in southwestern and south-central Newfoundland (B. J. Hearn, unpublished data).

Two explanations for this introduction are possible. Red-backed Voles may have been accidentally introduced in pulpwood or pulp chips imported through the port of Stephenville, (approximately 38 km SW of our sampling sites). Alternatively, the species may have been deliberately introduced by unknown persons to increase prey diversity and abundance for the Newfoundland Marten. Because Red-backed Voles are a common prey item in the diet of American Marten elsewhere (Martin 1994), this management option was debated during preparation of the Newfoundland Marten Recovery Plan (Forsey et al. 1995*), resulting in a divergence of opinions among local stakeholder groups. Although ultimately rejected by the Newfoundland Marten Recovery Team as an ethical recovery action, the limited prey base and the ecological consequences of introducing the Red-backed Vole were publicly discussed in 1998, during a two-day symposium on issues concern-

ing the Newfoundland Marten. Given the coincidence in timing (ca. 1998) and spatial distribution of this discovery (inside the PMSA), we suggest that it is likely that Red-backed Voles were deliberately introduced.

Regardless of the source of this introduction, the direct and indirect effects of this new species on community structure in general, and the Newfoundland Marten in particular, warrant investigation. As an example, Cameron (1958) reported that Newfoundland Meadow Voles are less selective in their habitat requirements than mainland Meadow Voles, and atypically, occupy forested habitats — likely due to the historical absence of Red-backed Voles (Cameron 1958; Clough 1964; Cameron 1965; Morris 1969; Folinsbee et al. 1973). Consequently, the introduction of the Red-backed Vole will probably result in a niche contraction for the endemic Meadow Vole, and we predict that Meadow Voles will be displaced from forested areas and restricted to their preferred habitat (i.e., moist meadow-like areas (Folinsbee et al. 1973)). Preliminary analysis of our 1999–2006 small-mammal trapping data from the RIL area is documenting an irrupting population of Red-backed Voles (>3000 Red-backed Voles captured since 2001), and an essential elimination of Meadow Voles from forested sites where we had previously captured Meadow Voles.

Consequently, the positive effect of increased prey diversity and biomass for the Newfoundland Marten will be offset, to some degree, by a decrease in distribution and densities of Meadow Voles, which have been a historically important prey species (Bateman 1986; Drew 1995; Gosse and Hearn 2005; Tucker 1988). Further, indirect effects of the Red-backed Vole on Newfoundland Marten could occur as a result of the impact of this species on local Red Fox (*Vulpes vulpes*) populations. Given the depauperate prey base in Newfoundland, Red Fox and Marten display considerable dietary overlap, and Red Fox are the most important natural predator of Newfoundland Marten (B. J. Hearn, unpublished data). Consequently, Marten may be negatively affected if the introduction of Red-backed Voles has a positive effect on Red Fox demography, leading to increased intraguild predation on Marten (Lindström et al. 1995) or increased Marten–Fox competition for food (Kurki et al. 1997; Lindström et al. 1994; Marcström et al. 1988). Pine Marten (*Martes martes*) populations in Scandinavia increased in the 1980s, following a decline of Red Fox due to a sarcoptic mange epidemic, as a direct result (hypothesized) of reduced predation by Red Fox (Lindström et al. 1994; Helldin 1998) or reduced competition for *Microtus* prey (Storch et al. 1990). Although counterintuitive to conventional competition theory, increases in food resources (prey availability) can actually increase intraguild predation by supporting increased populations of the superior competitor. Parallel circumstances have been described for other threatened or endangered carnivores elsewhere (e.g., Coyote predation on Swift Foxes (*Vulpes macrotis*) (Sovada et al. 1998), Coyote predation on San Joaquin Kit Foxes (*Vulpes macrotis*) (Ralls and White 1995; White and Garrott 1997; Cypher and Spencer 1998), and Lion (*Panthera leo*) and Spotted Hyena (*Crocuta croenta*) predation on African Wild Dogs (*Lycaon pictus*) (Creel 2001; Creel et al. 2001)). African Wild Dog densities are actually lowest where density of their major prey is highest, due to intraspecific predation (Mills and Gorman 1997). It is noteworthy that Marten live-trapping captures on the Northern Peninsula of Newfoundland increased in 2005 following a recent (2002-2004) rabies outbreak (Whitney 2004*) that virtually eliminated Red Fox from the local landscape (M. McGrath, personal communication).

Changes in prey availability clearly affect densities of carnivores, improving demographic performance (i.e., increased reproductive output and survival (Fuller and Sievert 2001). Furthermore, decreased food resources have been associated with reduced population density or trapper success, enlarged home ranges, and lower reproductive performance of American Marten (Bulmer 1974; Fryxell et al. 1999; Poole and Graf 1986; Simon et al. 1999; Thompson and Colgan 1987). The reduced prey base for Marten in Newfoundland compared with that available on the mainland portion of the province (Labrador) has been suggested as a likely explanation for the difference in the demographic health of these two populations (Bissonette et al. 1988*). By comparison, Labrador has 17 small mammal species, including the Red-backed Vole (Tucker 1988) and Marten populations appear capable of supporting a commercial harvest; 500-800 Marten were harvested annually between 1995 and 1998 (Simon et al. 1999).

However, an increase in vole biomass may not lead to an immediate increase in Marten densities if territory size in Newfoundland is adjusted to the lowest (or historical) level of prey availability. Such appears to be the case for European Badger (*Meles meles*) in Scotland (Kruuk and Parrish 1982), Kit Foxes in California (White and Ralls 1993), and some Coyote populations in the western United States (Mills and Knowlton 1991). Interestingly, Payer (1999) in the largest American Marten study reported to date ($n > 140$ marten ranges), found no difference in mean home-range area for American Marten in Maine between 1995-1998, despite a three-fold decline and recovery in small mammal populations. Thompson and Colgan (1987, 1990) suggested that, based on energetics, Marten in Ontario cannot survive exclusively on small rodents during late winter, and further, take small mammals opportunistically as they hunt for larger prey (i.e., Snowshoe Hare). Moreover, Gosse and Hearn (2005) reported that Snowshoe Hare provide >90% of the caloric intake of Newfoundland Marten in winter, the most energetically stressful period annually (Buskirk et al. 1988). As cautioned by Fuller and Sievert (2001), the correlation between food and density-related demo-

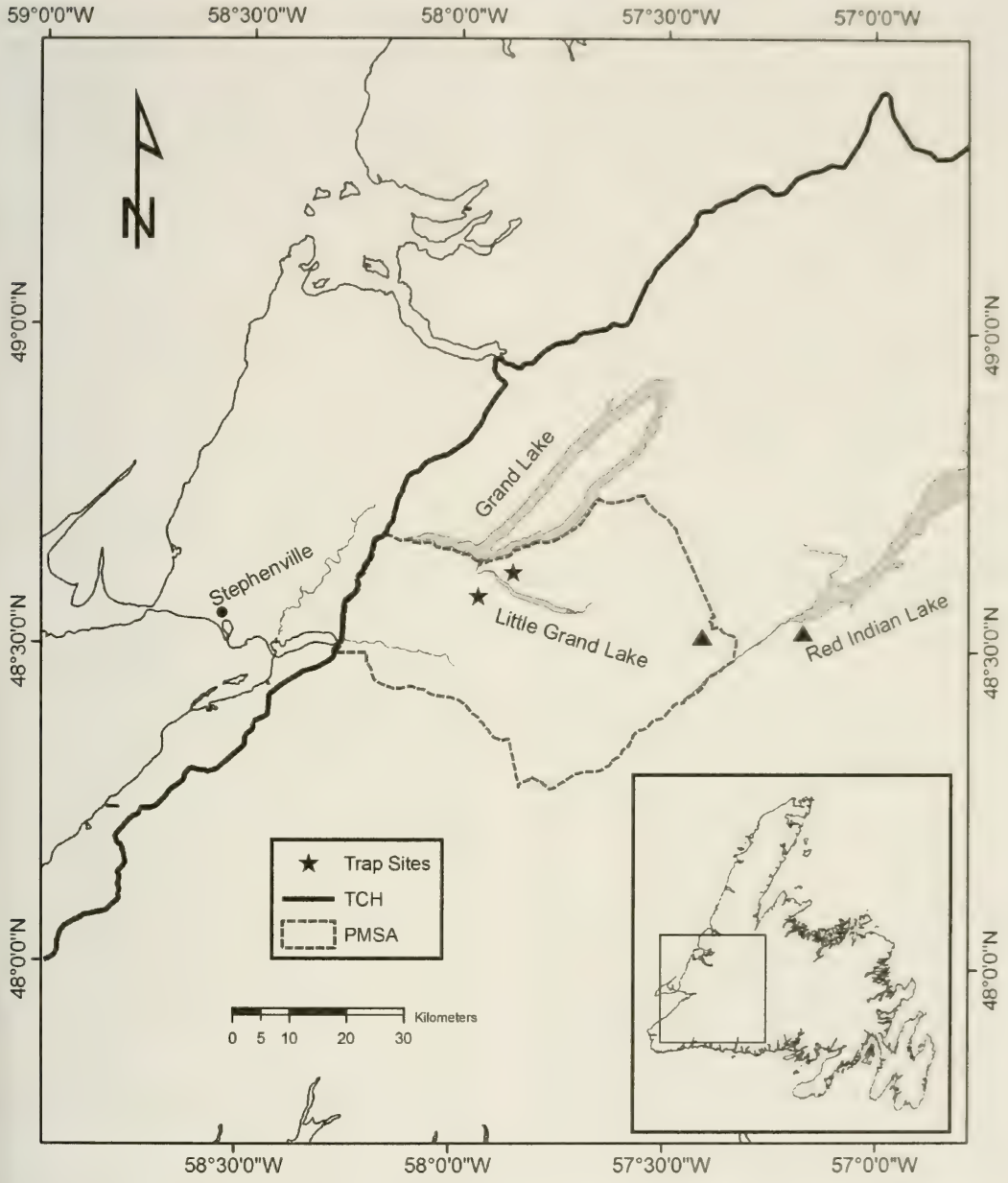

FIGURE 1. Map of southwestern Newfoundland showing location of Southern Red-backed Vole (*Clethrionomys gapperi*) captures in 1999, and capture sites relative to other areas mentioned in text; ▲ indicates location of first Southern Red-backed Vole capture in Red Indian Lake area in 2001. Inset map shows the location of areas relative to the island of Newfoundland.

graphic parameters is statistically broad, and many site-specific factors (e.g., prey availability, habitat patchiness, habitat selection under foraging versus predation-risk trade-offs), influence home-range characteristics and carnivore density.

Newfoundland Marten have been geographically and reproductively isolated from mainland Marten populations for the last 7000 years (South 1983), resulting in a genetically distinct subspecies amidst a much more genetically homogenous Canadian main-

land population (Kyle and Strobeck 2003). Additionally, Newfoundland Marten are large (males = 1254 g, n = 122; B. J. Hearn, unpublished data), and have extremely large home-range requirements (males = 30.8 km^2, n = 43; B. J. Hearn, unpublished data) compared with nearby mainland populations in Quebec (males = 937 g, n = 67; 7.4 km^2, n = 40; Potvin and Breton 1997) and Maine (males = 776 g, n = 23, Katnik 1992; 4.04 km^2, n = 96; Payer 1999). Collectively, these population characteristics suggest that the Newfoundland Marten is a product of a unique ecological setting and evolutionary selective factors operating on a geographically and reproductively isolated island population. Thus, it seems unlikely, given the historical ecological setting, that Newfoundland Marten spatial requirements evolved to access or select habitat (Hearn et al. 2005*) based on utilizing small mammals as prey.

We predict that the establishment of the Red-backed Vole on the island of Newfoundland will cause direct and indirect community-level effects in general and for Newfoundland Marten in particular (e.g., increased utilization of the Red-backed Vole as prey by Newfoundland Marten and Red Fox and associated demographic responses and interactions, more restricted habitat utilization by Newfoundland Meadow Voles, and changing utilization and dispersal of seeds by introduced Red-backed Voles and consequently changing plant regeneration patterns). The direct and indirect effects of previous introductions of non-native species to the island of Newfoundland have been previously described for predator–prey interactions (Bergerud 1971, 1983), plant successional patterns (Thompson et al. 1992, Thompson and Curran 1993), and species interactions (Benkman 1993).

Additional small mammal field surveys are being conducted to document the changing distribution of Red-backed Voles on the island and may offer additional information about the mechanism by which this species was introduced. In this regard, genetic analysis may be helpful in determining the source population for this introduction. Future field studies, in areas where Newfoundland Marten spatial characteristics have been well documented (Hearn et al. 2005*) are being considered to assess the effects of this new prey species on Newfoundland Marten population characteristics.

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Long-range Homing by an Adult Female Black Bear, *Ursus americanus*

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An adult female Black Bear was repeatedly captured and relocated as a result of nuisance behaviour. The relocation distances ranged from 40 km to 389 km (mean = 152 km, $n = 6$). She homed successfully from all relocations, even when accompanied by young-of-the-year. Differential homing ability among bears may depend on first homing from a short relocation, facilitating subsequent responses to longer distance relocations.

Key Words: Black Bear, *Ursus americanus*, homing, distance, relocation, translocation, Ontario.

The ability of animals to return home when removed from familiar territory has been recorded for several different species including: pigeons, *Columba* spp. (Papi 1992); Deer Mice, *Peromyscus maniculatus* (Bovet 1968; Teferi and Millar 1993); Red Squirrels, *Tamiasciurus hudsonicus* (Bovet 1995); Raccoons, *Procyon lotor* (Belant 1992); Wolves, *Canis lupus* (Fritts et al. 1984); and Brown Bears, *Ursus arctos* (Miller and Ballard 1982). The use of relocation as a management tool for nuisance bears has provided researchers with the opportunity to study the homing behaviour of a large mammal. Several studies conducted on Black Bears (*Ursus americanus*) have determined that a high proportion of relocated bears return to the capture area (Harger 1970; Alt et al. 1977; Rutherglen and Herbison 1977; McArthur 1981; Rogers 1986a; Shull 1994), with adult bears more likely to return to the capture area than juveniles (Harger 1970; Rogers 1986a; and Landriault 1998). During a four-year study of relocated nuisance Black Bears in Sudbury, Ontario (46°N, 81°W), one bear was successful in homing over an exceptionally long distance (Landriault 1998). This report describes her relocation and homing history, and briefly discusses factors that may affect homing success in relocated bears.

Animals were captured in large barrel traps or with the use of immobilization agents delivered via a dart gun or jab stick. In accordance with the study protocol, nuisance Black Bears were immobilized using a mixture of ketamine hydrochloride (Ketaset®) and xylazine hydrochloride (Rompun®) at a dosage of 4.4 mg/kg and 2.2 mg/kg, respectively. Captured bears were weighed, various body measurements obtained, and the animals were ear-tagged (Kurl-lock metal tags, Ketchum Manufacturing Inc, Brockville, Ontario). A premolar was extracted for ageing purposes. Some animals were fitted with a very high frequency (VHF) radio-transmitter collar (148 to 152 MHz range, Lotek Inc., Newmarket, Ontario). If re-captured, most bears were immobilized again to assess changes in condition by means of growth rates for juveniles and changes in weight for adults. The majority of capture and release locations were estimated using topographical maps or a hand-held global positioning system (GPS) unit; however, the only information available for the first and third captures described in this note was the township name. In these cases the center of the township was used to estimate release and homing distances. In the study area, townships were 10×10 km such that the center of the township could only be a maximum of 7 km from the true location. Distances presented in this report are straight-line measurements and do not take topographical features into consideration. Returning within 20 km of the capture site was defined as successful homing (Landriault 1998).

Adult female Black Bear LR04 was captured as a nuisance animal and relocated a total of 6 times (Table 1 and Figure 1). In all cases she was captured because she was foraging in improperly stored refuse at residences in suburban areas. She was initially captured as a nuisance animal in June of 1994. At this time, she was estimated to be 9 years of age based on the examination of premolar cementum annuli (Johnston et al. 1987). She was ear-tagged and relocated approximately 40 km south of the capture site. LR04 was recaptured in June of 1995, an estimated 6 km from her first capture location. She was lactating; however, no cubs were found. She was fitted with a radio-collar and relocated a second time, 105 km to the north. LR04 was subsequently recaptured in September of 1995, 7 km from her second capture location, and was accompanied by three cubs. The four bears were relocated as a family unit, approximately 112 km. LR04 was captured again in June of 1996, within 17 km of her previous capture location, accompanied by three yearlings. LR04 and two of the yearlings were relo-

TABLE 1. Relocation history of nuisance Black Bear LR04, including relocation distance, bearing, and proximity of consecutive capture and release sites. All capture locations are in the suburban areas of the City of Sudbury, Ontario. Body weight information has been included as a means to assess the general condition of the animal.

Capture date	Body weight (kg)	Proximity of capture site to previous capture site (km)	Relocation distance (km)	Proximity of release site to previous release site (km)	Bearing to relocation site
20 June 1994	65		40		166°
14 June 1995	76	6	105	141	325°
18 September 1995	147	7	112	6	325°
8 June 1996	67	13	166	76	343°
5 July 1996	82	10	389	222	330°
1 October 1997	140	< 1	100	290	323°

cated 169 km. LR04 was subsequently captured a fifth time in July of 1996, within 11 km of her previous capture site. She was not accompanied by any offspring. On this fifth relocation she was transported 389 km to the northwest and was recaptured in October of 1997, within 7 km of her previous capture location. At this time she weighed approximately 140 kg and was relocated 100 km.

From 1994 to 1997, adult female LR04 was relocated a total of six times, with relocation distances ranging from 40 to 389 km. She homed successfully in all cases and the maximum distance between any two capture sites was 10 km. The longest homing distance observed for this animal (389 km) appears to be a record distance for Black Bears. The true distance travelled by bear LR04 to return to her home range is expected to be much greater than 389 km, due to variations in topography and the probable deviations from straight-line homing as a result of landscape features, human habitation, foraging, and interactions with other animals. Other observations of long-range homing in relocated Black Bears include animals returning from distances of 99 km (Rutherglen and Herbison 1977) and 229 km (Harger 1970) on the Upper Peninsula in Michigan, 103 km in the Rocky Mountains of British Columbia (Erickson and Petrides 1964), and 182 km in Central Ontario (Landriault 1998). Although all of these observations are from adult animals, in some instances juveniles can home from long distances. As part of the same study, a juvenile female homed from a relocation distance of 92 km (Landriault 1998). The differential homing ability of adults versus juveniles has been attributed to an established home range and to experience gained during seasonal foraging excursions (Anderson et al. 1977; Rogers 1986b, Rogers 1987a).

Juvenile male Black Bears generally disperse between 2 and 4 years of age, prior to establishing home ranges. In contrast, juvenile females generally take up residence in their maternal home range (Rogers 1987b; Schwartz and Franzmann 1992). It has been hypothesized that bears without established home ranges have limited homing success due to a lack of effort rather than ability (Anderson et al. 1977; Rogers 1986b). As predicted by this hypothesis, lower homing success has been observed in juvenile males than in adults and juvenile females (Harger 1970; Rogers 1986a; and Landriault 1998). Adult females would benefit from a strong desire to return to their established home range where they have been able to meet the nutritional requirements necessary for reproduction (Rogers 1976; LeCount 1982; Elowe and Dodge 1989; Kolenosky 1990) and have successfully avoided fatal conflicts for them and/or their young, with local conspecifics (Jonkel and Cowan 1971; Tietje et al. 1986).

Experience would also be expected to increase an animal's homing success. Many Black Bears cover extensive area during yearly foraging excursions (Rogers 1987a) and these foraging excursions may allow bears to develop orientation and homing skills, resulting in increased homing success with age. Many young bears may not have gained enough experience to home successfully from significant distances.

It is unknown whether bear LR04 would have homed from 389 km had she been relocated that distance after her initial capture. It is possible that repeated relocations result in training individual bears to home from long distances. Black Bears that home successfully after the first relocation are likely to be successful after all subsequent relocations of increasing distance (Blanchard and Knight 1995; Landriault 1998), suggesting that homing ability in bears is enhanced with experience. Homing pigeons are commonly trained by gradually increasing the displacement distance from the home loft, and young birds displaced too far early in their training do not home successfully (Papi 1992). The successful return from a relatively short distance appears to enhance homing effort and/or skill, and increases the chance of success from longer distances.

The desire for adults to return to an established home range, combined with experience acquired in navigating over long distances, appears to explain why adult bears are more adept at homing. The inadvertent training of bear LR04 by gradually increasing the reloca-

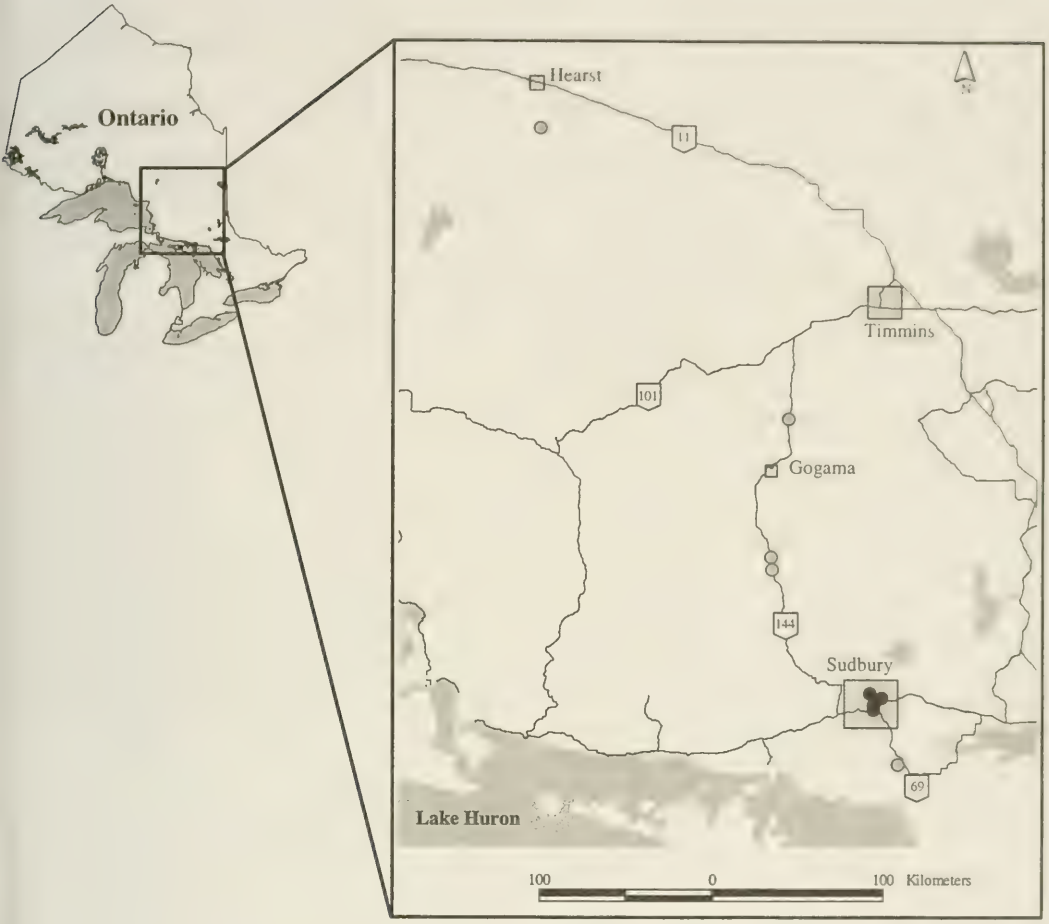

FIGURE 1. Capture and release locations for nuisance Black Bear LR04. Black circles represent the capture locations and grey circles represent release locations. The thin black lines on the map correspond to the two-lane paved provincial highways along the relocation routes, while the shaded squares are cities and small towns along these routes. Irregular shaded areas are lakes.

ion distances may explain how she was able to home successfully over a longer distance than any previously reported for a Black Bear.

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Early Ontogenetic Diet in Gray Wolves, *Canis lupus*, of Coastal British Columbia

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Within populations, different age classes often consume dissimilar resources, and provisioning of juveniles by adults is one mechanism by which this can occur. Although the diet of Gray Wolves (*Canis lupus*) has been studied extensively, the diet of pups is largely unknown. We examined faeces deposited by altricial pups and adult providers during the first two months following birth at two den sites over two years on the central coast of British Columbia, Canada. Pups and adult wolves consumed similar species, and Black-tailed Deer (*Odocoileus hemionus*) constituted most of the diet for both age groups. Pup and adult diet, however, diverged. Specifically, adult deer occurred significantly less frequently in the diet of pups than in the diet of adult wolves, which suggests that adults selectively provisioned pups. We speculate that this may relate to adaptive strategies of adult wolves to provide their offspring with food of optimal nutritional value or reduced parasitic burden, and or logistic factors associated with provisioning such as prey transportability and availability.

Key Words: Gray Wolf, *Canis lupus*, Sitka Black-tailed Deer, *Odocoileus hemionus*, provisioning, pups, diet, British Columbia.

Different age classes within a species often consume dissimilar resources, increasing population niche width and decreasing intraspecific competition (Polis 1984; Bolnick et al. 2003). Provisioning of young by adults is one mechanism whereby differences in diet between young and adults may occur (Markman et al. 2002). Foragers that select foods to optimize growth and development of their offspring may have a selective advantage over those that provision their young opportunistically (Krebs and Avery 1984; Wright et al. 1998). Providers may select resources that are easy to transport (Molsher et al. 2000) or that have nutritional qualities important for developing juveniles (Krebs and Avery 1984). Furthermore, providers may alter their behaviour while rearing young to reduce exposure of their offspring to parasites (Christe et al. 1994; Merilä and Allander 1995; Tripet et al. 2002).

Young Gray Wolves (*Canis lupus*) rely predominantly on food killed and delivered by closely related adult providers for many months (Paquet and Carbyn 2003). Although diets of adult wolves have been studied extensively, the diet of juvenile wolves has not been well documented in any system (Paquet and Carbyn 2003).

Wolves of coastal British Columbia (BC) have a potential niche that includes up to 15 mammal species (Darimont and Paquet 2000*, 2002; Darimont et al. 2004), which likely differ in transportability, nutritional characteristics, and parasite load. Herein, we investigated potential age class differences in diet by examining faeces of pups and adults deposited at den sites within the first two months following birth for two social groups over two breeding seasons. Our objectives were to describe the diet of adult and juvenile wolves during the denning season and examine whether the diet of pups differed from that of adults. Given the ubiquity of evidence from a variety of other systems, we predicted that adult wolves would selectively provision food resources to developing pups.

Study Area

We collected faeces from two home sites (i.e., reproductive areas) on the central coast of British Columbia in July of 2001 and 2002. The study area has been described well elsewhere (Darimont and Paquet 2002; Darimont et al. 2004). One site was located on Chatfield Island (area: 48 km^2; distance from mainland: 1 km; centre island location: 52°16'N, 128°05'W) and the other on Yeo Island (98 km^2; 0.25 km; 52°21'N, 128°08'W). Both sites were <100 m ASL (above sea level). During the study, social groups were composed of 3-7 pups and 3-8 adults. Potential prey species include Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*), mustelids, ursids, birds, rodents, fish, and marine mammals and invertebrates (Darimont and Paquet 2000*, Darimont et al. 2004).

Materials and Methods

Scat collection and analysis

Both sites were on or within 50 m from transects monitored for faeces during spring (April/May) before arrival of wolves or birth of pups, and summer (July) after wolves had left the areas. Thus, we are confident that faeces collected during July represent resources

acquired during May and June, at which time pups were approximately 2-8 weeks old. This period also corresponds to the birth pulse of many prey in the area, including deer (Shackleton 1999).

In all cases, wolves had moved to another site by July, so we sampled all or most faeces that surrounded the abandoned sites (within ~100 m). Based on diameter, we subjectively classified faeces (n = 479) as those deposited by pups or adults. In July, pup faeces are easy to distinguish from those of adults and there is no overlap in diameter (Weaver and Fritts 1979). The few faeces that were mostly liquid or suggestive of severe weathering (i.e., amorphous shape or irregular surface; n ~ 20), which we felt could not be accurately classified, were discarded.

Faeces were autoclaved, washed, and dried so that only macroscopic components such as hair, bone, teeth, and hooves remained (Cuicci et al. 1996). To identify mammalian prey items, we examined the entire sample with the naked eye to detect hair clumps that differed in colour, size and/or texture from others, and other clues such as teeth, claws and hooves. Subsequently, we microscopically examined five sub-samples, randomly selected via a grid system in the sample tray, which typically contained five to 10 hairs each. We identified species by comparing with a reference hair collection, as well as cuticular scale imprints using dissecting and compound microscopes and dichotomous keys (Mayer 1952; Adorjan and Kolenasky 1969). We differentiated between adult deer and fawn hair using a combination of diameter and colour characteristics (Scott and Shackleton 1979). Birds and invertebrates were identified by feathers, claws, shell fragments, and cuticles and were scored as present or absent. Using an 8 × 10 grid of 1-cm squares, we estimated the percentage of prey species in each faeces.

All faeces were analyzed by one observer (HB) to eliminate inter-observer bias (Spaulding et al. 2000). Before faecal analysis, we tested observer accuracy with a reference collection and scored 92% (23 out of 25 correct). Following identification of prey remains, we also assessed precision and scored 100% (25/25) on classification of taxa. Finally, we investigated our precision in assessing adult/fawn categorization. We classified 77% (17/22) correctly. This bias, however, was directional: we scored five adults incorrectly as fawns.

Data analysis

We used two indices in analysis. Percentage of whole scat equivalents (pWSE) is the mean percentage of each prey species found per faeces (Angerbjörn et al. 1999; Elmhagen et al. 2002). For example, two faeces containing deer and seal in percentages of 40,60 and 60,40 respectively, would have pWSE of 50 for both prey species. Percent occurrence per item (O/I) is the number of occurrences of each prey species divided by the total number of items identified, where an item is defined as an occurrence of a prey species in an individual faeces (Theberge et al. 1978).

We used log-linear analysis on pWSE data to test for differences in diet between pups and adult wolves while simultaneously assessing influences of years and sites. We excluded birds and invertebrates from this analysis because conversion to pWSE was not possible on presence/absence data. These items occurred infrequently and were never found alone in faeces. In this log-linear analysis, we also combined non-deer items into an "other" category due to infrequent occurrence (see Results).

To measure dietary breadth of both age classes, we used Levin's Measure, standardized on a scale from 0 to 1 (Hurlbert 1978; Krebs 1999; Elmhagen et al. 2002). Levin's measure of dietary breadth, B_A, is calculated using pWSE data as follows:

$$[1] \qquad B_A = \left[\frac{1}{\sum p_i^2} - 1\right] \Big/ (n-1)$$

where p_i is the proportion of resource i in a diet consisting of n resources.

We also calculated dietary overlap between age classes using Schoener's measure (p_{jk}; Shoener 1970) and Horn's index (R_o; Horn 1966). Both calculations indicate food-niche overlap between populations j and k, where p_{ij} and p_{ik} are the proportions of resource i in diets, and n is the number of available resources. Although Shoener's measure is frequently used and therefore comparable to other literature, Horn's index is less biased under changing numbers of resources, sample size, and resource evenness (Krebs 1999). Calculations were performed on pWSE data.

$$[2] \qquad p_{jk} = \left[\sum^{n} (\text{minimum } p_{ik}, p_{ij})\right] 100$$

$$[3] \qquad R_o = \frac{\sum (p_{ij} + p_{ik}) \log (p_{ij} + p_{ik}) - \sum p_{ij} \log p_{ij} - \sum p_{ik} \log p_{ik}}{2 \log^2}$$

Results

Pup and adult wolves consumed a breadth of resources; however, Sitka Black-tailed Deer constituted most of the diet for both age classes (Table 1). Deer represented 54.6 to 100% of whole scat equivalents, depending on site and year, and accounted for 50.0 to 98.4% of all prey items (Table 1). After deer, Harbour Seal (*Phoca vitulina*), invertebrates, and birds were the most common prey items, whereas Beaver (*Castor canadensis*), Short-tailed Weasel (*Mustela ermina*), Mink (*Mustela vison*), River Otter (*Lutra canadensis*), Marten (*Martes americana*), and Fisher (*Martes pennati*) occurred infrequently in the diets of pups and adult wolves (Table 1). Pups and adults had

Table 1. Prey items identified in the feces of pup ($n = 240$) and adult ($n = 239$) wolves from home sites on Chatfield and Yeo Islands, coastal British Columbia in 2001 and 2002. pWSE is proportion of whole scat equivalents, where *n* represents the number of whole scat equivalents. O/I is percent occurrence per item, where *n* represents the number of items in all feces. Invertebrates are marine invertebrates (e.g., crabs, bivalves). Categories with zero prey items are represented by (–).

	Chatfield Island								Yeo Island							
	2001				2002				2001				2002			
	Pup		Adult		Pup		Adult		Pup		Adult		Pup		Adult	
	n=35 pWSE	*n*=48 O/I	*n*=91 pWSE	*n*=141 O/I	*n*=57 pWSE	*n*=60 O/I	*n*=48 pWSE	*n*=50 O/I	*n*=86 pWSE	*n*=88 O/I	*n*=56 pWSE	*n*=62 O/I	*n*=62 pWSE	*n*=62 O/I	*n*=43 pWSE	*n*=46 O/I
Black-tailed Deer	54.6	50	71.7	53.2	100	95	100	96	100	97.7	94.6	88.7	98.4	98.3	95.3	91.3
Adult	28.6	25	43.5	33.3	36.8	35	58.3	56	36	35.2	58.9	56.5	53.2	53.2	65.1	60.9
Fawn	25.7	25	28.3	19.9	63.2	60	41.7	40	64	62.5	35.7	32.3	45.2	45.1	30.2	30.4
Other (Mammals)	45.7	45.9	28.3	25.5	–	–	–	–	–	–	5.4	4.8	1.6	1.6	4.6	6.5
Harbour Seal	45.7	43.8	23.9	22	–	–	–	–	–	–	3.6	3.2	–	–	–	–
Mink	–	–	2.2	2.1	–	–	–	–	–	–	–	–	–	–	–	–
River Otter	–	–	–	–	–	–	–	–	–	–	–	–	1.6	1.6	2.3	4.3
Short-tailed Weasel	–	2.1	1.1	0.7	–	–	–	–	–	–	–	–	–	–	–	–
Marten	–	–	–	–	–	–	–	–	–	–	1.8	1.6	–	–	2.3	2.2
Fisher	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Beaver	–	–	1.1	0.7	–	–	–	–	–	–	–	–	–	–	–	–
Bird	N/A	2.1	N/A	5	N/A	5	N/A	4	N/A	–	N/A	–	N/A	–	N/A	–
Invertebrates	N/A	2.1	N/A	16.3	N/A	–	N/A	–	N/A	2.3	N/A	4.8	N/A	–	N/A	2.2

similar dietary breadths (Table 2). Average percent dietary overlap between pup and adult wolves was 79%, whereas Horn's index showed a considerably higher average dietary overlap of 0.96 (Table 2).

A major difference between pup and adult diet was the proportion of different age classes of deer consumed. Pups consumed a lower proportion of adult deer and a higher proportion of fawn compared with adults (Partial $\chi^2 = 17.77$, df = 2, $P<0.001$; Table 1). The magnitude of this difference varied across years and locations (association between location, age class of wolf, and prey item; Partial $\chi^2 = 7.73$, df = 2, $P = 0.02$; Table 1). A high proportion of seal on Chatfield Island in 2001 caused the 3-way association (Table 1). Accordingly, when we excluded seal from log-linear analysis, the association between location, age class of wolf, and prey item was not significant (Partial $\chi^2 = 0.20$, df = 1, $P = 0.65$). We then found, similar to other areas and years, that pups consumed a significantly smaller proportion of adult deer than did adult wolves at both locations (Partial $\chi^2 = 17.91$, df = 1, $P<0.001$).

Discussion

A large body of literature exists regarding wolf diet but it primarily addresses spatial and temporal patterns (Paquet and Carbyn 2003; Peterson and Cuicci 2003) and not other aspects of intrapopulation variability. Relatively little dietary information exists in the context of raising young. Exceptions include two studies that found significant differences in the diet of adult wolves between den sites and nearby areas (Theberge et al. 1978; Meleshko 1986). Neither study, however, differentiated between pup and adult diet as we do here.

Herein, we show that juvenile and adult wolves from two coastal islands have similar niches at the prey species level, as they have similar dietary breadth and moderate overlap. These results show that adult wolves provide pups with food items similar to themselves and are not hunting distinct prey species for pups. At a finer resolution, however, we show that diets differ between pups and adults, which we infer as evidence for selective provisioning. Controlling for location and year effects, our log-linear results showed that pups were supplied a smaller proportion of adult deer than consumed by adults.

The difference we detected could be influenced by limitations in prey identification methods. Results of our precision test show a possible directional bias in categorization of deer age class towards fawns. The direction (or magnitude) of the difference between pup and adult diet, however, would not be affected and thus we consider this possible bias unimportant. Regardless, this demonstrates the importance of testing for, and reporting on, precision (and accuracy), which is extremely rare in dietary studies on wolves or other taxa (cf. Fritts and Mech 1981; Cuicci et al. 1996; Darimont et al. 2004).

TABLE 2. Dietary breadth and overlap as inferred by fæcal collection from den sites of pup and adult Gray Wolves, coastal British Columbia, summers 2001 and 2002.

	Chatfield Island		Yeo Island		Average
	2001	2002	2001	2002	
Dietary breadth					
Pup	0.37	0.87	0.21	0.35	0.45
Adult	0.41	0.95	0.27	0.32	0.49
Dietary overlap					
Percent Overlap	79	79	72	86	79
Horn's Index	0.95	0.97	0.93	0.98	0.96

Selective provisioning occurs if diets of providing adults and altricial young differ, and evolves when the behavior is advantageous for reproduction or survival. Well-described in birds (e.g., Martin 1987; Wright et al. 1998), we suspect this behaviour is common in wolves and potentially other mammals. Although we have no data to indicate why adult wolves selectively provision pups, several "logistic" and adaptive explanations are plausible.

While likely rooted in adaptive value, provisioning strategies probably are shaped further by logistic or environmental factors that affect the relative benefits and costs of providing care to young. First, adults may selectively provision resources such as whole fawns or portions of fawns because they are easy to transport to young (e.g., Molsher et al. 2000). Ease of transport may be particularly important when pups are old enough to consume solid prey items. Other important factors affecting wolf foraging, and subsequent provisioning, are spatial and temporal variation in prey abundance (e.g., Theberge et al. 1978; Meleshko 1986), which would then interact with how pack members divide the provisioning labour. Contributions to young by each member would depend on age, experience, hunting habits, social status, and genetic relatedness to offspring (Mech et al. 1999). For example, pup diets could be biased if individual wolves such as the mother or father target fawn and provision at a higher frequency than other pack members.

Among several adaptive hypotheses, we speculate that parents may base provisioning decisions on nutritional requirements of developing young. For example, protein is important for growing animals (Robbins 1993) and may be particularly important in large carnivores such as wolves (Lauer et al. 1969). If protein content drives provisioning, then a greater proportion of high-protein resources would be expected in the diet of young wolves. Based on published values, there is no difference in protein content between age classes of deer (Percent body weight = 20.3 for both fawn [$n = 7$], and adult [$n = 16$] White-tailed Deer, *O. virginianus*; means calculated from Robbins 1973). This suggests that protein is not a driving factor in provisioning we observed.

Differences in body fat among prey might contribute to adaptive provisioning behaviour. Body mass, which is often associated with consumption of fatty resources in large mammals, is important for survivorship for both providers and offspring (Derocher and Stirling 1996). Of major prey items in this study, seal had the highest fat content (percent body weight = 23.6 [$n = 35$], Harbour Seal; Coltman et al. 1998) followed by adult deer (Percent body weight = 12.8, [$n = 16$], White-tailed Deer; mean calculated from Robbins 1973) fawn (percent body weight = 3.1 [$n = 7$], White-tailed Deer; mean calculated from Robbins 1973). Although pups consumed more high-fat prey items (seal) than adult wolves on Chatfield Island in 2001, they consumed less high-fat prey items (adult deer) than adult wolves at all locations. This suggests that adult wolves may provide their young with high-fat food only when there is an abundance of high-fat prey items. Otherwise, it is possible that adults may be selectively retaining prey items of higher fat content, which may represent a benefit controlled by provisioners in what potentially is a parent-offspring (or in this case, provider-receiver) conflict (Trivers 1974).

Wolves may provision according to potential parasite load in prey, which may provide the best adaptive explanation for the pattern we observed. As ungulates and other animals age, their parasite burden often increases (Crooks et al. 2001). Increasing prevalence of parasitic infection with age has been found in White-tailed Deer (Bogaczyk et al. 1993), Marsh Deer (*Blastocerms dichotomus*), and Pampas Deer (*Ozotocerus bezarticus;* Ferreira et al. 1997). Although we could not find similar studies on black-tailed deer, we postulate that comparable disease dynamics occur in this species.

Many studies have shown that parasites are important in parental care strategies (Christe et al. 1994; Merilä and Allander 1995; Moreno et al. 1999; Tripet et al. 2002). Young animals have naive immune systems, as they have not been exposed to a wide variety of pathogens (Hutchings et al. 2002). Low levels of exposure to pathogens can help young develop immunity but high levels can have severe consequences on survival. Therefore, gradual introduction of pathogens

to young animals by providers is likely important, which an early diet biased towards fawns may achieve.

Avoiding excessive exposure to parasites may be particularly important in wolves, given their life history. Wolves are k-selected organisms, investing considerably in relatively few offspring. Furthermore, populations demonstrate a type I survivorship curve. Survival in pups, although not well studied, is thought to be typically lower compared with resident adults (Fuller et al. 2003). Pup mortality is often related to or influenced by diseases, many of which exploit prey as intermediate hosts (Kreeger 2003).

Future studies could address logistic and adaptive hypotheses we have presented herein and their possible interaction. In summary, we suggest that selective provisioning strategies should now be considered among the behaviours of wolves and one that contributes to maximizing lifetime reproductive output.

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Extension of Coyote, *Canis latrans*, Breeding Range in the Northwest Territories, Canada

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Cluff, H. Dean. 2006. Extension of Coyote, *Canis latrans*, breeding range in the Northwest Territories, Canada. Canadian Field Naturalist 120(1): 67-70.

Coyotes (*Canis latrans*) have resided in the Northwest Territories for several decades but have only rarely been sighted north of Great Slave Lake (>62° N. latitude) in the Taiga Shield ecozone. Records show Coyotes have been seen since the 1960s. Prior to 2000, evidence of Coyotes breeding in the Taiga Shield has been anecdotal. In 2000, a Coyote was repeatedly seen at the Yellowknife airport and in 2001, a pair of Coyotes was observed with two pups. Since then, Coyote pups have been observed annually at the airport and adult Coyotes are seen regularly within the city of Yellowknife, an urban island within the Taiga Shield ecozone. Unlike in most regions occupied by Coyotes, medium-sized prey are rarely seen. Recently, Coyotes have become a potential hazard to aircraft at the Yellowknife airport. Although Coyotes appear to have established themselves within the city of Yellowknife, maintaining a presence beyond the urbanized area remains uncertain.

Key Words: Coyote, *Canis latrans*, distribution, range extension, reproduction, Northwest Territories.

Coyotes (*Canis latrans*) have been uncommon in the Northwest Territories (NWT) north of Great Slave Lake (north of the 62nd parallel). Banfield (1974) and Voigt and Berg (1987) suggested Coyote distribution was limited to the Taiga Plain ecozone and did not extend beyond the northwest shore of Great Slave Lake where the Taiga Shield ecozone begins. The Taiga Shield ecozone is characterized by a patchwork of wetlands, forests, meadows, and shrublands situated on top of glaciated bedrock with numerous lakes and rock outcrops. Summers are short and winters are long and cold. Although sightings of Coyotes beyond current range limits may be expected, occurrences of reproduction beyond the Taiga Plain and into the Taiga Shield would be less likely. Bekoff (1977) and Bekoff and Gese (2003) estimated the range of Coyotes to be further northward but their delineation appears based on the northern limit of trees ("tree-line"). This paper reports on recorded sightings and breeding of Coyotes in the Taiga Shield ecozone in northwestern Canada. I identify current conflicts and management responses for Coyotes as their numbers have increased in a northern urban area.

Methods

I recorded and investigated Coyote sightings in the Yellowknife area since summer 2001. I solicited sighting and harvest information from wildlife officers, hunters, and trappers in the Northwest Territories and western Nunavut. I searched historical records for Coyotes among fur harvest records, Wolf (*C. lupus*) bounty receipts, and annual reports. Carcasses of Coyotes obtained since 2001 were examined whenever possible.

Results and Discussion

The earliest recorded sighting of Coyotes in the Taiga Shield ecozone occurred in the Yellowknife area in the early 1960s. In winter 1974-1975, five Coyotes were observed in the Long Lake area near the Yellowknife airport (J. Hordal, Hay River, Northwest Territories, personal communication). Prior to 2000, three other sightings occurred outside (>40 km) of the Yellowknife area (Figure 1) and in the late 1960s, a trapper shot a Coyote on Stark Lake, east from Lutsel K'e (formerly Snowdrift) (A. Boucher, Lutsel K'e, Northwest Territories, personal communication). One Coyote was occasionally sighted at the Yellowknife airport in 2000 and in spring 2001, two adult Coyotes were often reported near the airport; two pups were observed later that summer, the first documented occurrence of Coyotes breeding this far north in the Northwest Territories.

There have been two oral reports of Coyotes at Kugluktuk (67°49'N, 115°06'W), Nunavut, near the northern coast of mainland Canada. Although exact dates and written reports are absent, the sightings are noteworthy as they occurred on the tundra 40-60 kilometres beyond the tree-line. The first was by a hunter who shot a Coyote 70 km west of Kugluktuk around 1988. The second was circa 1997 when two hunters saw a Coyote southwest of Bloody Falls on the Coppermine River (A. Niptanatiak, Kugluktuk, Nunavut, personal communication).

The presence of Coyotes at the Yellowknife airport is not surprising because the area is characterized by open grassy habitat in contrast to the surrounding boreal forest. Rodents, birds, hares, and other wildlife on the airport property serve as food. The availability of food

scraps near the city of Yellowknife proper and at the city dump should contribute to a continued presence by Coyotes within the urbanized area. It is possible that the Coyotes observed near the Yellowknife airport in winter of 1974-1975 had bred in the area as three of the five Coyotes did not appear adult size (J. Hordal, personal communication).

Coyotes in northern urban areas

The existence and colonization of Coyotes in and around Yellowknife is of concern to residents and airport authorities. Residents are primarily concerned for the safety of their pets. Airport authorities are concerned as Coyotes and their pups occupy the Yellowknife airport property and represent an air safety risk. In 2002, 2003 and 2004, 2, 7, and 4 pups were observed on the airstrip area respectively (S. Loutitt, Yellowknife airport, personal communication). Coyotes have not been limited to the airport. Seven were observed together on Back Bay in Yellowknife on 9 December 2004 (J. Bastedo, Yellowknife, personal communication) representing the largest number of Coyotes observed together within Yellowknife to date. In addition, a Coyote pup was found dead on 30 August 2004 (J. Bastedo, personal communication) and another Coyote pup was road-killed on 29 October 2004, both within Yellowknife city limits. Furthermore, on 21 October 2004, a Coyote pup was killed on the highway about 60 kilometres northwest of Yellowknife and may represent a separate litter (Figure 1).

The origin of this newest incursion of Coyotes is unknown, although they may have followed the single highway corridor connecting Yellowknife to the south. Coyotes have been expanding their range elsewhere over recent decades and human-induced habitat changes are likely contributory (Moore and Parker 1992; Chubbs and Phillips 2002; Chubbs and Phillips 2005). Factors that might discourage Coyotes from colonizing northward include morphology, behaviour, and reproduction (Phillips 1982). Although not morphologically equipped for travel in areas with deep snow, Coyotes might overcome this limitation by using trails and areas with hard snow (Murray and Boutin 1991; Murray and Larivière 2002). Wolves often kill coyotes where their ranges overlap (Krefting 1969; Paquet 1989; Crabtree 1998), further discouraging northern Coyote range expansion.

Air-strike risk

Coyotes at the Yellowknife airport present a public safety risk because of aborted take-off and landing attempts and potential for collisions causing property damage and personal injury (B. Webber, Yellowknife airport, personal communication). Although the airport perimeter is fenced, Coyotes can access the area through holes in the chain-link or by digging underneath. Continual removal efforts would be required to be effective over the long-term.

Although Coyotes have the potential to cause significant damage to small planes, those struck at southern airports are often hit by undercarriage and do little overall damage to the aircraft (Dolbeer et al. 2000; Cleary et al. 2004). The greater risk is from aborted take-off and landings (Dolbeer et al. 2000), as pilots tend to see Coyotes on runways before collisions occur.

There is anecdotal evidence that Coyotes may disperse other wildlife at airports such as Sandhill Cranes (*Grus canadensis*), Red Fox (*Vulpes vulpes*), and deer (*Odocoileus* sp.), and thus reduce the overall risk of wildlife strikes by aircraft (R. Dolbeer, United States Department of Agriculture, personal communication; S. Loutitt, personal communication). Coyotes are known to predate on Red Fox in some southern regions (Voigt and Earle 1983; Sargeant et al. 1987; Harrison et al. 1989), although fox predation by Coyotes has not yet been reported at the Yellowknife airport. There are few site-specific wildlife studies that address relative abundance and spatial patterns of wildlife at airports (Hoffman et al. 1996; Dolbeer et al. 2000). The dilemma at the Yellowknife airport is one of risk management. Airport management staff believe co-existence is possible and have chosen not to eliminate Coyotes but to monitor their presence and reduce numbers when required.

Coyote persistence

Whether Coyotes remain in the Yellowknife region is uncertain, although they occupy similar habitat elsewhere (e.g., Alaska; Labrador). Coyotes expanded their range northwest to Alaska in the late 1800s by scavenging along trails left by the gold rush (Gier 1975) and arrived in the Yukon by 1910 (Parker 1995). Coyotes appeared in the Northwest Territories fur harvest in the early 1930s when records were first kept. Suppressants to early colonization of Coyotes in the Yellowknife region include hunting, trapping, predation by Wolves, and incidental mortality at poison baits during Wolf control in the early 1960s (Heard 1983; Cluff and Murray 1995). Wolves are occasionally observed at the Yellowknife airport, and in 2004 a pack of five were reported within city limits.

To sustain a Coyote population a reasonable prey base must exist. Birds, Snowshoe Hare (*Lepus americanus*) and other small mammals would be the main source of food for forest-dwelling Coyotes (Crête et al. 2001). White-tailed Deer (*O. virginianus*) are only rarely sighted in the Taiga Shield (unpublished data; Veitch 2001). Wood Bison (*Bison bison athabascae*) have expanded their range into the area since 1999 but this may adversely impact Coyotes if Wolf numbers also increase. Garbage and domesticated animals in the Yellowknife area would augment the available food supply. The Yellowknife city dump, electrified only in summer against Black Bears (*Ursus americanus*), is not a barrier to Coyotes. Cabins and homes scattered on the landscape outside of Yellowknife may also supply

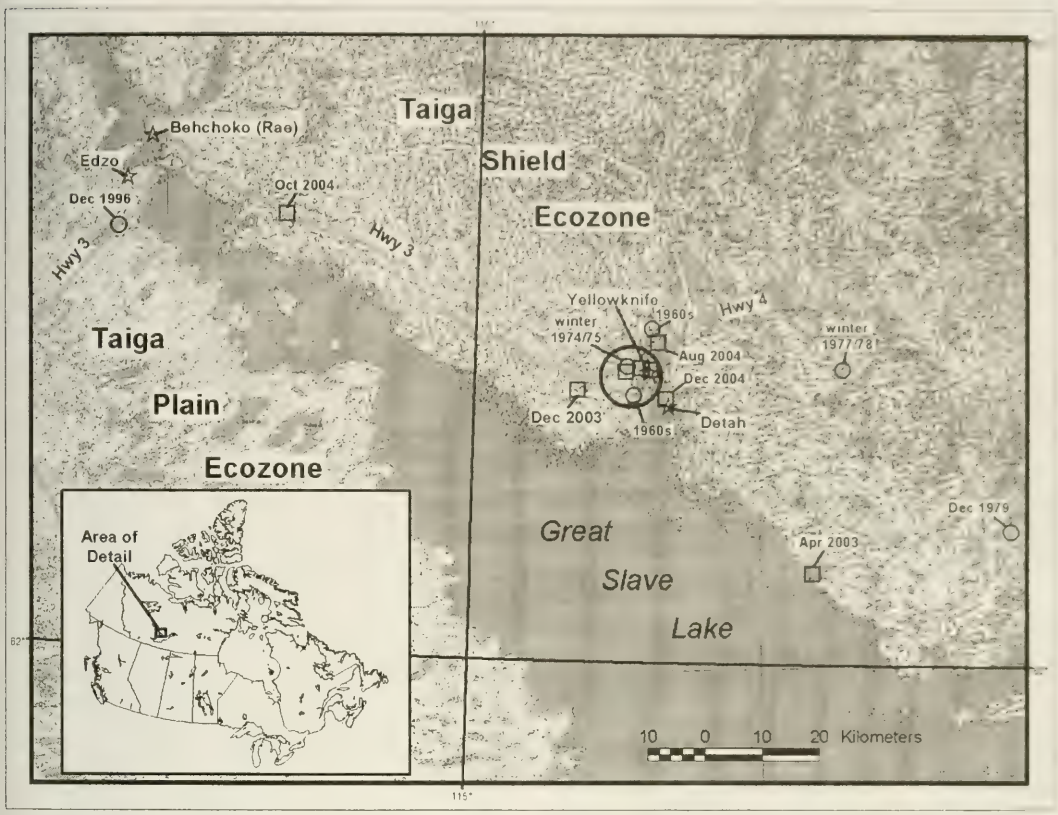

FIGURE 1. Taiga Plain and Taiga Shield ecozones bordering Great Slave Lake in the Northwest Territories showing records of Coyotes since the 1960s documented in text. Circles represent sites prior to 2000, squares in 2003 and 2004.

food. Consequently, Coyote persistence in Taiga Shield of the Northwest Territories may be strongly linked to a suburban environment, especially if an inadequate prey base exists elsewhere. How the public and wildlife management authorities choose to deal with Coyotes as urban carnivores will be a key factor for Coyote persistence in the Yellowknife region.

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Lake Sturgeon, *Acipenser fulvescens*, Movements in Rainy Lake, Minnesota and Ontario

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Adams, W. Eugene, Jr., Larry W. Kallemeyn, and David W. Willis. 2006. Lake Sturgeon, *Acipenser fulvescens*, movements in Rainy Lake, Minnesota and Ontario. Canadian Field-Naturalist 120(1): 71-82.

Rainy Lake, Minnesota-Ontario, contains a native population of Lake Sturgeon (*Acipenser fulvescens*) that has gone largely unstudied. The objective of this descriptive study was to summarize generalized Lake Sturgeon movement patterns through the use of biotelemetry. Telemetry data reinforced the high utilization of the Squirrel Falls geographic location by Lake Sturgeon, with 37% of the re-locations occurring in that area. Other spring aggregations occurred in areas associated with Kettle Falls, the Pipestone River, and the Rat River, which could indicate spawning activity. Movement of Lake Sturgeon between the Seine River and the South Arm of Rainy Lake indicates the likelihood of one integrated population on the east end of the South Arm. The lack of re-locations in the Seine River during the months of September and October may have been due to Lake Sturgeon moving into deeper water areas of the Seine River and out of the range of radio telemetry gear or simply moving back into the South Arm. Due to the movements between Minnesota and Ontario, coordination of management efforts among provincial, state, and federal agencies will be important.

Key Words: Lake Sturgeon, *Acipenser fulvescens*, biotelemetry, Rainy Lake, Ontario, Minnesota.

Movement patterns of Lake Sturgeon (*Acipenser fulvescens*) were relatively unstudied through the early 1970s (Scott and Crossman 1973). However, in the past decade, Lake Sturgeon movements have been studied at an increasing rate throughout much of the species' range (Rusak and Mosindy 1997; McKinley et al. 1998; Auer 1999; Borkholder et al. 2002; Knights et al. 2002). Lake Sturgeon have been found to move large distances for purposes such as spawning (Threader and Brosseau 1986; Fortin et al. 1993; Rusak and Mosindy 1997; Auer 1999) while maintaining smaller ranges in other systems (Bassett 1982*). Such movement patterns make Lake Sturgeon management difficult, particularly for multiple agencies dealing with border waters of substantial size.

Rainy Lake, a border water shared by Minnesota and Ontario, contains a Lake Sturgeon population that has gone largely unstudied. Lake Sturgeon in this system have been segregated from upstream Namakan Lake and downstream Lake of the Woods/Rainy River system populations by dams constructed on the outlets of Rainy and Namakan lakes early in the 20th century. The Lake Sturgeon is a Minnesota state-listed species of special concern (Minnesota Department of Natural Resources 2003*), while The Committee on the Status of Endangered Wildlife in Canada considers western populations of Lake Sturgeon to be endangered and the Rainy River-Lake of the Woods populations to be of special concern (Environment Canada 2005*).

Management of the Lake Sturgeon population in Rainy Lake is a cooperative effort among the Ontario Ministry of Natural Resources, the Minnesota Department of Natural Resources, and the United States federal government. Movement of Lake Sturgeon across international borders leads to an increase in importance of appropriate harvest regulations and an understanding of movement patterns and spawning locations. Such information will allow managers to protect areas that are important for Lake Sturgeon spawning.

The objective of this descriptive study was to determine generalized Lake Sturgeon movement patterns in Rainy Lake through the use of biotelemetry. Movement data obtained from tagged Lake Sturgeon were organized using a geographic information system (GIS) and used to help identify seasonal movement patterns and potential spawning locations.

Study Site

Rainy Lake, located on the Minnesota-Ontario border, consists of three main basins: the North Arm, Redgut Bay, and the South Arm, all of which are part of the Winnipeg-Nelson drainage system in the Lake Winnipeg primary watershed (Figure 1). The North Arm and Redgut Bay are both located entirely in Canada. Rainy Lake has a total surface area of 92 000 ha, a maximum depth of 49.1 m, and a mean depth of 9.9 m. Of the three main lake basins, the South Arm has the greatest surface area at 49 200 ha, with 27 300 ha in Ontario and 21 900 ha in Minnesota. The South Arm is also the deepest basin with a mean depth of 9.9 m and a maximum depth of 49.1 m. The South Arm extends for 56 km along the border of the United States

and Canada. The South Arm of Rainy Lake, along with a 40-km section of the Seine River, was the area of focus for this study.

The watershed associated with Rainy Lake encompasses over 37 500 km^2 and can be divided into two sub-basins, including a 19 270-km^2 area above the outlet of Namakan Reservoir at Kettle Falls and Squirrel Falls and a 19 320-km^2 area below Kettle Falls and Squirrel Falls that drains directly to Rainy Lake. Overflows between Namakan Reservoir and Rainy Lake also occur at Bear Portage and Gold Portage. Below Kettle Falls and Squirrel Falls there are two principal tributaries that enter Rainy Lake, the Turtle River with a mean discharge of 37 m^3/sec and the Seine River with a mean discharge of 48 m^3/sec. Smaller, ungauged tributaries into the South Arm of Rainy Lake include the Rat and Pipestone rivers, both of which may be used by Lake Sturgeon for spawning. Changes in flow initiated at the headwaters of the watershed take about 21 days to reach the outlet of Rainy Lake under normal flow conditions with the water dropping about 135 m in the 338 km between these two points (International Rainy Lake Board of Control/ International Lake of the Woods Control Board 1984*). Long-term flow records indicate that approximately 8.3 billion m^3 of water move through the Rainy Lake watershed annually (Ericson et al. 1976*).

Methods

Biotelemetry was utilized in the identification and characterization of Lake Sturgeon seasonal movement patterns and likely spawning locations in Rainy Lake. Lake Sturgeon were captured for transmitter implantation in October of 2002 (n = 13), May and June of 2003 (n = 20), and October of 2003 (n = 8) at the mouths of tributaries where they were known to concentrate (tagging locations are noted in Table 1). Large mesh multifilament gill nets with mesh sizes of 103, 114, 127, 152, and 178 mm (bar measure; i.e., distance from knot to adjacent knot) were used to capture fish. Net lengths varied from 30 to 91 m, with all nets having a height of 1.83 m. Most nets were fished for approximately 24 hours, but actual times varied among sampling crews. Captured Lake Sturgeon were measured, weighed, sex was noted if gonads were identifiable during surgery, and a pectoral fin ray section was removed for aging (Adams et al. 2006).

Lotek Wireless combined acoustic/radio transmitters (CART) were surgically implanted into 41 Lake Sturgeon (≥8 kg) throughout the duration of this study. Thus, only a single tag was implanted and used for both radio and acoustic tracking, with the radio portion of the tag allowing tracking of fish in shallow or turbulent habitats, while the ultrasonic portion of the tag was needed for tracking of Lake Sturgeon in deeper habitats (Winter 1996). Surgical implantation procedures followed guidelines set by Hart and Summerfelt (1975). A 5- to 8-cm incision was made on the ventral fish surface approximately 3 cm off the midline and approximately 3 cm from the anterior end of the pelvic girdle. A 0.5-cm exit hole for the whip antenna was started with a scalpel on the midline approximately 3 cm posterior to the incision. A curved, 12-gauge catheter needle was passed through the hole and out through the incision with care taken to not penetrate or cut the viscera. The whip antenna projecting from the CART tag was then threaded though the end of the catheter needle that was protruding through the incision with the antenna being passed out of the peritoneal cavity through the antenna hole. The CART tag was then inserted into the peritoneal cavity with minimal pressure exerted on the internal organs. Fish were placed in a holding pen following implantation, if necessary. When full equilibrium was regained, fish were placed in the water at the site of capture and monitored until they vacated the area. All fish handling and surgery followed guidelines for use of wild fishes established by Nickum et al. (2004).

Lotek CART 16-2 series tags were implanted in 33 Lake Sturgeon with the remaining eight fish receiving CART 16-1 series tags. Lotek CART 16-2 tags were 16 mm × 85 mm with a weight in air of 36 g, while Lotek CART 16-1 tags were 16 mm × 60 mm with a weight in air of 25.3 g. Implanted CART tags did not exceed 2% of the total body weight of any given fish (Gallep and Magnuson 1972; McCleave and Stred 1975; Stasko and Pincock 1977; Moser et al. 1990).

Aerial tracking of Lake Sturgeon occurred at least once per week throughout the spring spawning season and summer months when the airplane was operational. Transects were flown covering the eastern half of the South Arm, with every flight including a 40-km stretch of the Seine River that flows into Rainy Lake. Transects were chosen to maximize area covered with the least amount of flight time. The remaining portion of the South Arm was flown at least once every two flights, time and weather permitting. The North Arm of Rainy Lake was flown once in the summer of 2003 in an attempt to locate a fish that could not be located in the South Arm.

Radio tracking by boat took place on average two to three times per week depending upon weather conditions. Tracking was also dependent on time availability, with partial and full days devoted to boat tracking when possible. Locations highly used by Lake Sturgeon were sampled by boat during May and June because recognition of individual signals was difficult from the airplane.

Distributional patterns of Lake Sturgeon were summarized by month during the spawning period (May and June) and by two-month periods throughout the rest of the summer (July/August and September/October). Movement rates were calculated as the linear distance between successive fixes divided by the number of elapsed days. Lake Sturgeon home ranges were calculated using the Animal Movement extension in

FIGURE 1. Rainy Lake, Minnesota and Ontario. The line across the South Arm indicates the border between Canada and the United States.

ArcView 3.2 (Hooge et al. 1999*), with home ranges estimated by using minimum convex polygons (White and Garrett 1990). Home ranges included only water area; land masses were excluded.

Lake Sturgeon eggs were sampled during 2004 in an attempt to confirm spawning locations. Egg collectors were set weekly from 7 June through 1 July in three areas of high Lake Sturgeon use. Collectors consisted of an 18-m mainline of vinyl-coated wire cable (4.8 × 6.4 mm) with cement blocks (203 × 406 × 102 mm) attached at 3-m intervals and wrapped in furnace filter material. Floats were attached to each end of the mainline and egg collectors were set in shallow water areas of 0.3 to 4.6-m depth. Egg collectors were checked once weekly during the entire time period in which they were deployed. A sample of all egg types present on the collectors was removed and transported back to laboratory facilities to be hatched and the fry subsequently identified.

Results and Discussion

Lake Sturgeon tagging and survival

Forty-one Lake Sturgeon were implanted with CART tags during 2002 and 2003 (Table 1). Individual Lake Sturgeon were re-located between 0 and 36 times. No mortalities were positively identified. However, fish 99, implanted in October of 2003, was not located during the remainder of the study. Fish 30 was not located for 12 months after it was tagged and released, but then was subsequently located 11 times throughout the remainder of the study. Fish 106 was found at the same location, adjacent to the Seine River First Nations village on the Seine River, weekly for 11 weeks. We later learned that fish 106 may have perished in a gill net used in the Seine River First Nations subsistence fishery that had been left on the bottom of the Seine River due to entanglement with the substrate. All other fish were located at least once throughout the study.

Lake Sturgeon implanted with CART tags had a mean fork length of 1217.4 mm (range 951-1505 mm), girth of 502.4 mm (range 372-639 mm), mass of 15.35 kg (range 7.5-30 kg), and age of 25.9 (range 15-55) (Table 1). These ranges were representative of the Lake Sturgeon population in Rainy Lake at the time of this study (Adams et al. 2006).

Transmitter detection

Acoustic equipment was tested during the spring of 2003. Tags were lowered at 2-m intervals between

TABLE 1. Fish description, transmitter code, and capture location at time of tagging for Lake Sturgeon implanted with Lotek CART transmitters in Rainy Lake, 2002-2003. Ages were determined from pectoral fin ray sections. NA = not available.

Code number	Tagging date Month/day/year	Total length (mm)	Fork length (mm)	Girth (mm)	Weight (kg)	Sex*	Age	Tagging location
1	10/2/02	NA	1100	444	11.5	FI	22	Canadian Channel
2	5/21/03	1506	1433	635	30	F	55	Brule Narrows
3	10/9/02	NA	1210	556	19	FM	26	Stokes Bay
4	10/9/02	NA	1275	615	22.5	FM	27	Canadian Channel
5	10/9/02	NA	994	372	8	MM	15	Stokes Bay
6	10/9/02	NA	1050	425	9.5	Unk	19	Stokes Bay
7	10/9/02	NA	951	395	7.5	MM	17	Squirrel Falls
8	10/8/02	NA	1212	485	16	Unk	28	Squirrel Falls
9	10/8/02	NA	1313	582	20.5	FM	32	Canadian Channel
10	10/8/02	NA	1386	614	23.5	FM	28	Canadian Channel
11	10/8/02	NA	1447	639	30	FM	31	Stokes Bay
12	10/8/02	NA	1388	585	22.5	FM	26	Kettle Falls
13	10/8/02	NA	1200	445	13.5	Unk	18	Squirrel Falls
14	10/8/02	NA	1125	407	11.5	Unk	19	Squirrel Falls
15	5/28/03	1372	1260	495	14.5	Unk	21	Kettle Falls
16	5/20/03	1400	1270	503	16.5	Unk	NA	Brule Narrows
17	5/28/03	1404	1300	520	16.75	MM	21	Kettle Falls
18	5/28/03	1410	1285	475	15	MM	35	Kettle Falls
19	6/18/03	1270	1140	410	9.5	M	32	Kettle Falls
20	5/28/03	1200	1060	415	9	MM	20	Kettle Falls
21	6/18/03	1425	1280	570	20	FM	30	Squirrel Falls
22	5/28/03	1505	1365	545	1935	FM	27	Kettle Falls
23	6/18/03	1120	1000	460	11	Unk	21	Kettle Falls
24	5/21/03	1460	1315	578	20.75	FM	22	Brule Narrows
25	5/20/03	1379	1260	525	18	Unk	26	Brule Narrows
27	5/23/03	1640	1505	585	19.25	FM	47	Seine River
30	5/29/03	1444	1291	595	17.5	F	29	Squirrel Falls
39	5/23/03	1555	1429	580	22	FM	47	Stokes Bay
43	5/29/03	1335	1205	520	16.5	FI	22	Stokes Bay
51	5/29/03	1180	1063	405	8.5	Unk	19	Seine River
56	5/23/03	1575	1443	589	16	Unk	44	Seine River
63	5/23/03	1135	1025	435	8	Unk	18	Seine River
69	5/28/03	1280	1140	410	10	F	23	Rat River Bay Mouth
75	10/8/03	1449	1325	568	21	F	NA	Seine River
82	10/7/03	1400	1275	486	12.5	Unk	31	Brule Narrows
87	10/8/03	1095	997	431	8	Unk	18	Seine River
93	10/8/03	1265	1134	442	10.5	M	16	Seine River
99	10/8/03	1217	1094	450	9.5	Unk	16	Brule Narrows
106	10/8/03	1288	1186	461	12	M	18	Seine River
111	10/8/03	1272	1138	467	11.5	M	25	Seine River
119	10/8/03	1160	1045	480	10.5	Unk	19	Seine River

*F = female, maturity unknown; FM = female, mature; FI = female, immature; M = male, maturity unknown; MM = male, mature; Unk = sex unknown

2 and 20 m. The highest maximum detectable distance from the boat was 0.95 km when the CART tag was lowered to 6 m. The lowest maximum detectable distance of 0.53 km occurred at a tag depth of 18 m. The mean maximum detectable distance was 0.65 km with a standard error of 0.04. Limitations in the performance of the acoustic portion of the tags led to the discontinuation of acoustic telemetry from the study beginning during July of 2003. No fish locations were recorded with the acoustic equipment despite attempts on 10 dates between 15 May and 15 June 2003. The complexity of the bottom contours of Rainy Lake may have been the reason for the lack of reception of the directional acoustic signal.

Radio telemetry equipment was also tested. The highest maximum detectable distance from the boat was 0.47 km when the CART tag was lowered to 2 m. The lowest maximum detectable distance of 0.017 km occurred at a tag depth of 20 m. The mean maximum detectable distance was 0.21 km with a standard error of 0.05. The maximum detectable distance by airplane with the tag lowered to 8.77 m was 0.55 km with a standard error of 38.5.

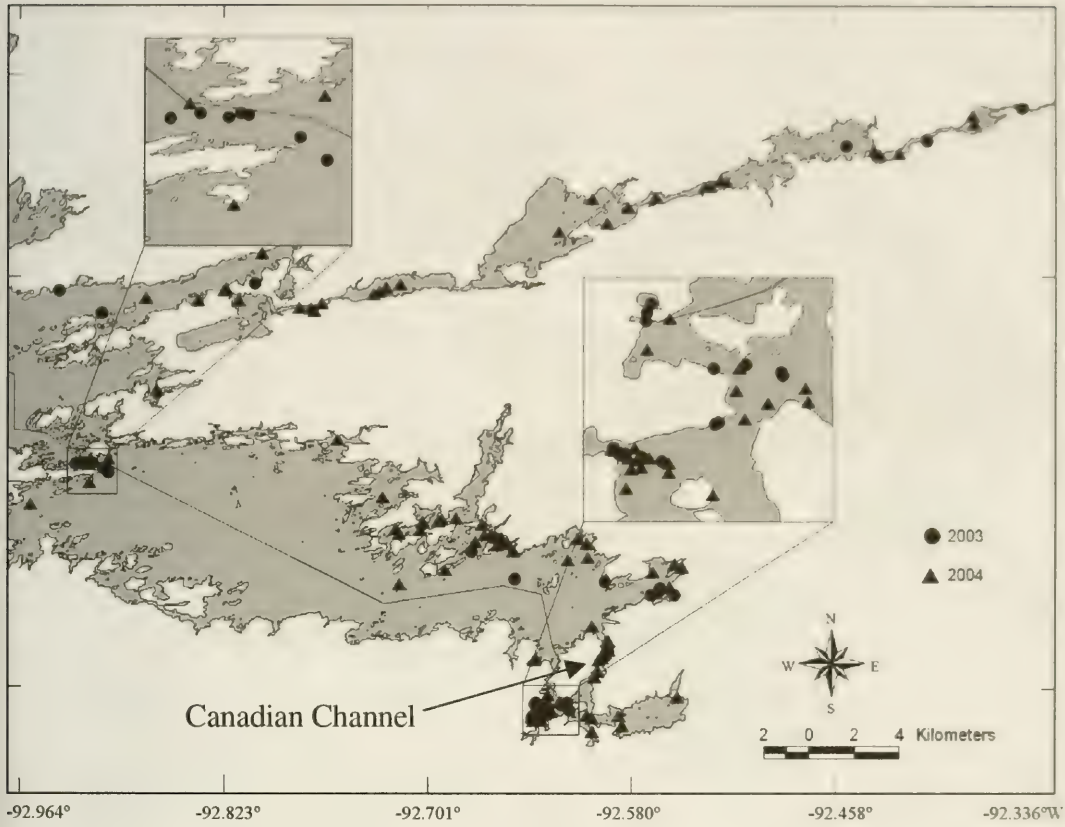

FIGURE 2. Distribution of Lake Sturgeon locations in Rainy Lake during May and June, 2003 and 2004.

Lake Sturgeon locations

The 41 implanted Lake Sturgeon were located 587 times throughout the study, with fish being tracked through September 2004. In 2003 Lake Sturgeon were located 285 times and in 2004 Lake Sturgeon were located 302 times.

Lake Sturgeon utilized Squirrel Falls/Kettle Falls and adjacent areas (Canadian Channel, Hale Bay) extensively throughout the study (37% of total locations, including both spawning and non-spawning seasons). A rock shelf below the Squirrel Falls Dam is one of the areas thought to be a spawning site for Lake Sturgeon in Rainy Lake. Egg samplers were placed below the Squirrel Falls Dam, in the Canadian Channel, and below the falls in the Pipestone River in 2004. Lake Sturgeon spawning, verified by hatching eggs and identifying larvae, was confirmed only at the Squirrel Falls Dam and occurred between 14 June and 17 June of 2004. Thus, we cannot exclude the possibility of spawning at other locations, but were able to verify spawning below the Squirrel Falls Dam. Other sites with Lake Sturgeon spawning habitat characteristics as listed by Scott and Crossman (1973) (e.g., 0.6-4.6 m depth, swift current, below falls) include the Kettle Falls Dam, Pipestone River, Rat River, and the Seine River (Crilly Dam and Highway 11 Bridge). Lake Sturgeon were located at all of these sites throughout the study, including the spawning season.

The majority of May locations (89%) for both 2003 (85%) and 2004 (90%) were associated with the current area directly below Kettle Falls, Squirrel Falls, and in the Canadian Channel (Figure 2), which suggests pre-spawning aggregations. Four of the other six May locations were associated with the Brule Narrows, also an area with consistent current.

Fewer Lake Sturgeon were located in the Kettle Falls/Squirrel Falls/Canadian Channel area as June progressed in both years (Adams 2004*). We suspect that Lake Sturgeon gradually left the spawning areas at Kettle Falls and Squirrel Falls, and dispersed primarily to the main basin east of Brule Narrows. During this month, Lake Sturgeon locations in the Seine River were spread throughout Seine Bay and 36 km upriver. The increased number of Seine River locations from 2003 to 2004 was due to the increased number of tagged Lake Sturgeon. Only four fish from the Seine River were tagged for 2003 tracking, while six additional fish were tagged for 2004 tracking.

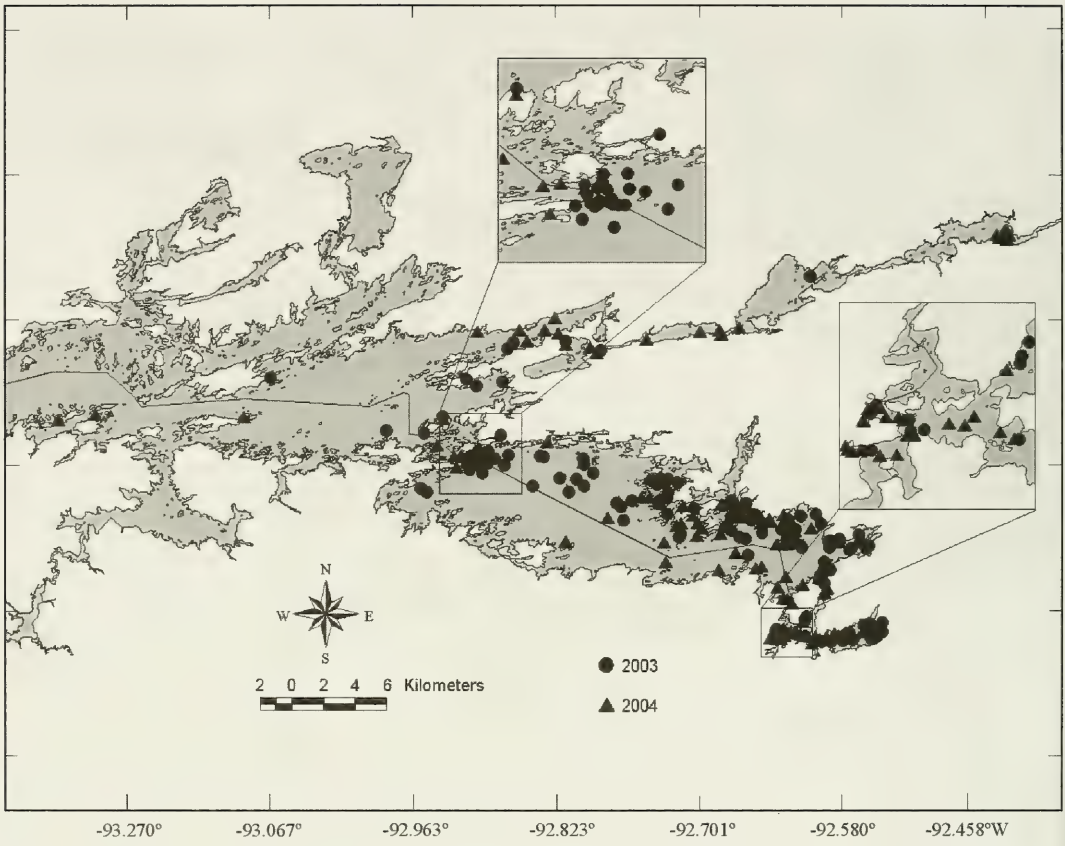

FIGURE 3. Distribution of Lake Sturgeon in Rainy Lake during July and August, 2003 and 2004.

During the July/August period, the majority of Lake Sturgeon were found from the Brule Narrows eastward and in the Seine Bay/Seine River system, with only five locations found west of the Brule Narrows (Figure 3). Some Lake Sturgeon continued to be located in the Kettle Falls/Squirrel Falls area during this period in both years (15 locations and 35 locations, respectively). Locations in the main body of the South Arm were associated with the north shore more than the south shore during this time period (96% in 2003 and 84% in 2004). There are substantial habitat differences between the two areas with the south shore consisting of a sharp drop-off into depths of over 30 m. Conversely, the north shore consists of rock reefs and depths shallower than 15 m. Either the fish were less likely to use the deeper water, or the lack of locations was due to limitations of the telemetry equipment with radio signals detected from depths no greater than 18 m.

September locations were obtained during both 2003 and 2004 with October locations obtained only in 2003. Locations during this time period were distributed throughout the South Arm (Figure 4). Locations in the Seine River were few, with zero in 2003 and two in 2004. Fish 75 was tagged in the Seine River but located in the South Arm during this time period. Lake Sturgeon were located on the south shore of the South Arm for the first time in September. One potential explanation is that Lake Sturgeon were staging at locations in the vicinity of winter habitats. Rusak and Mosindy (1997) found that Lake Sturgeon in the Lake of the Woods/Rainy River system demonstrated consistent preferences for specific areas in the main basin of Lake of the Woods during the winter; these areas were adjacent to the mouth of the Rainy River where the Lake Sturgeon would later spawn in the spring.

Lake Sturgeon movement rates

Mean movement rates of Lake Sturgeon were calculated by month for descriptive purposes (Figure 5). Movement rates increased from May to June during 2003 and 2004, with a maximum movement rate of 0.80 km/day in June of 2004 and a minimum movement rate of 0.17 km/day in May of 2003. Movement rates in five of the 10 months exceeded the mean spring

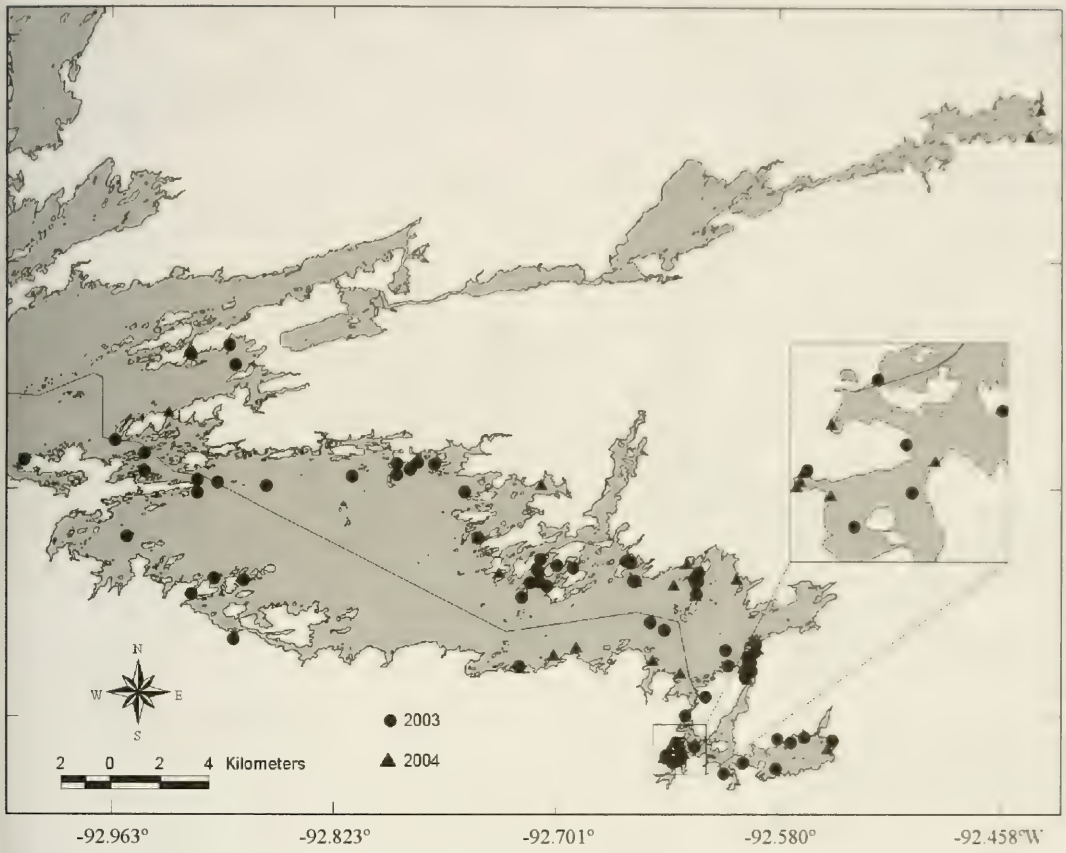

FIGURE 4. Distribution of Lake Sturgeon locations in Rainy Lake during September and October 2003 and September 2004.

movement rate of 0.50 km/day observed by Knights et al. (2002) for Lake Sturgeon in the upper Mississippi River system. Lake Sturgeon in Rainy Lake likely were dispersing into the lake away from spawning sites during the post-spawn period in June. However, movement rate patterns were dissimilar for the same months between years. Further research thus will be needed to ascertain seasonal movement patterns and explanations for those patterns.

Movement of fish between the Seine River and the main body of the South Arm did occur but was minimal throughout the study. Rusak and Mosindy (1997) found that in the Lake of the Woods/Rainy River system, there was a separation in the population based primarily on winter habitat use. "River" fish spawned in the Rainy River and remained there throughout the winter months. "Lake" fish spawned in the Rainy River but moved into the main basin of Lake of the Woods during the winter months. If a similar dichotomy exists in the Rainy Lake/Seine River population, there may be greater movement of Lake Sturgeon between these two areas during the time period in which we did not attempt to locate fish (i.e., late fall and winter). Thus, Lake Sturgeon may move from Rainy Lake into the Seine River during this time period, but further investigation will be needed.

Movement patterns varied for individual Lake Sturgeon in Rainy Lake. Some fish did not exhibit discernable movement patterns, such as fish 21, which was located throughout the east end of the South Arm from Stokes Bay to the Brule Narrows and also in Seine Bay and at the mouth of Seine Bay (Figure 6). Locations in 2003 began in the east and moved west with the last location east of the Brule Narrows. The first locations in 2004 were in the Seine Bay/Seine River area with the remainder of locations further east. One factor contributing to the differential patterns between years may be the spawning interval exhibited by Lake Sturgeon, which ranges between 1 and 3 years for males and 4 and 6 years for females (Magnin 1966).

Telemetry results from Rainy Lake suggest that some Lake Sturgeon remained in the same area for

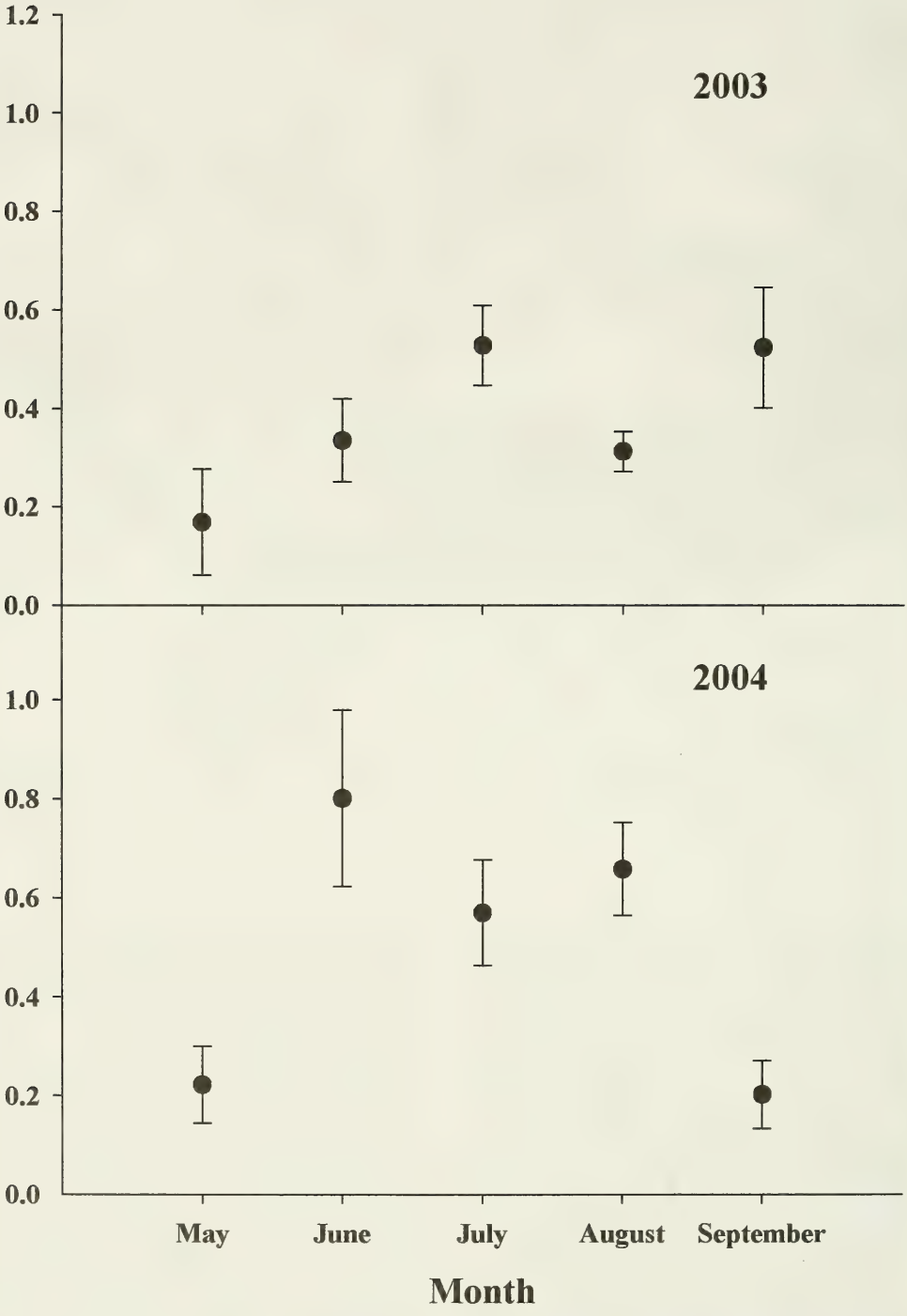

FIGURE 5. Mean monthly movement rate (± standard error) of Lake Sturgeon in Rainy Lake during 2003 and 2004.

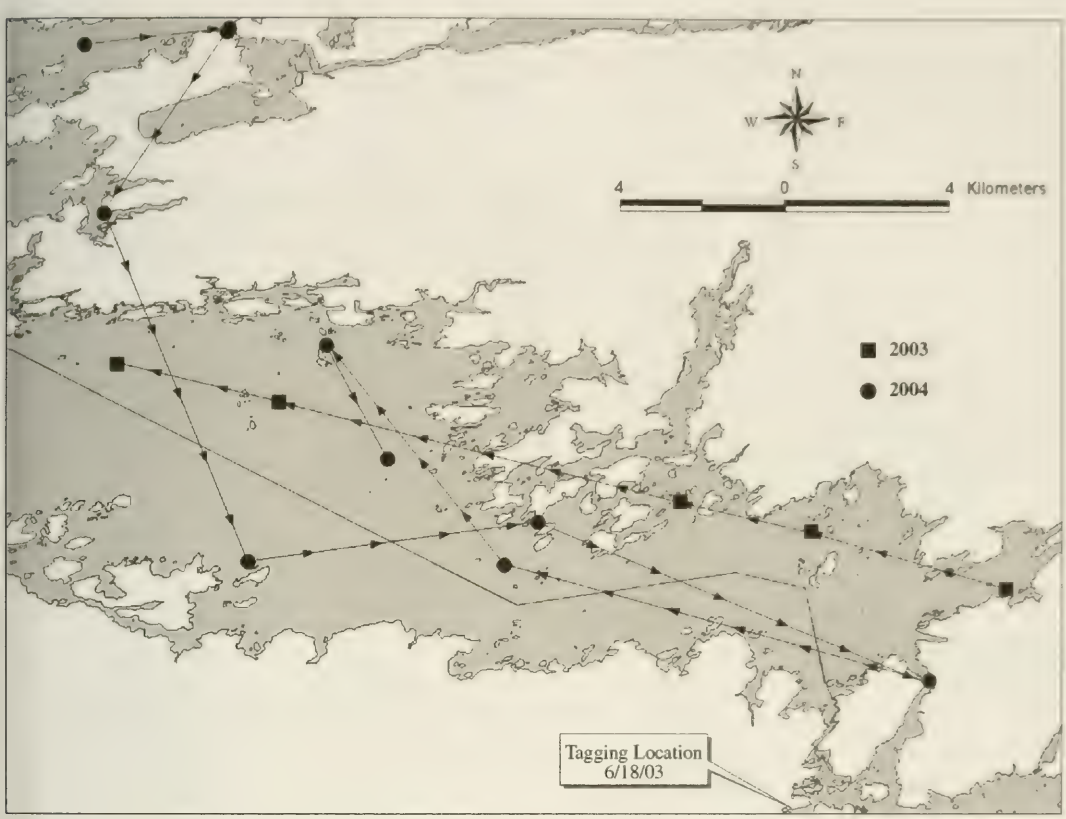

FIGURE 6. Distribution of locations for Lake Sturgeon number 21 in Rainy Lake, 2003 and 2004.

extended periods. For example, fish 15 was tagged at the Squirrel Falls Dam on 28 May 2003 and was next located in the Brule Narrows area (Figure 7). Subsequent locations were all in the area of the Brule Narrows until 26 August 2003. The next locations were in the Squirrel Falls Dam area beginning on 28 September 2003. The fish was then located in the Squirrel Falls Dam area on 18 May 2004 and was not located in the Brule Narrows area until 30 June 2004.

Lake Sturgeon home ranges

Home ranges for Lake Sturgeon in Rainy Lake varied substantially, with a maximum home range size of 14 844 ha, a minimum size (excluding fish 106, possible mortality) of 84 ha, and a mean home range size of 4 625 ha (standard error = 642). Lyons and Kempinger (1992*) reported that most Lake Sturgeon in the Lake Winnebago system had consistent movement patterns, while others demonstrated variable movement patterns and apparently did not establish home ranges. They also found that Lake Sturgeon in Lake Winnebago did not remain in any particular location for long periods of time.

Conclusions

This research should provide biologists from multiple agencies insight into general movement patterns of Lake Sturgeon inhabiting Rainy Lake. Telemetry data indicated high utilization of the Squirrel Falls area, with 37% of total locations occurring at that area. Squirrel Falls was the only site at which spawning was confirmed by collection of Lake Sturgeon eggs, although other aggregations in areas associated with Kettle Falls, the Pipestone River, and the Rat River also could indicate spawning activity. Movement of Lake Sturgeon between the Seine River and the South Arm of Rainy Lake indicates the likelihood of one integrated population on the east end of the South Arm. The lack of locations in the Seine River during the months of September and October might result from Lake Sturgeon moving into deeper water areas of the Seine River and out of the range of telemetry gear or simply moving back into the South Arm. Further research will be needed to determine the winter range of Lake Sturgeon in Rainy Lake. The Lake Sturgeon has historically been a resource of both cultural and economic importance to the Rainy Lake area. Due to

TABLE 2. Home ranges and mean movement rates (SD) by year for Lake Sturgeon in Rainy Lake. Missing values (dots) indicate that a fish was located zero or one times that year and thus movement could not be calculated.

Fish number	Total locations	Home range (ha)	Mean movement rate 2003 (km/d)	Mean movement rate 2004 (km/d)
1	25	2164	0.320 (0.22)	0.265 (0.31)
2	12	7758	0.170 (0.14)	0.564 (0.26)
3	17	2985	0.267 (0.20)	0.372 (0.33)
4	7	14844	0.619 (0.50)	.
5	13	3779	0.285 (0.33)	0.510 (0.36)
6	15	5416	0.448 (0.70)	0.663 (0.72)
7	23	3558	0.289 (0.28)	1.065 (0.74)
8	20	7277	0.076 (0.05)	0.554 (1.11)
9	11	8600	0.156 (0.20)	.
10	29	11894	0.808 (0.67)	0.977 (1.29)
11	17	10501	0.309 (0.23)	0.382 (0.23)
12	12	578	0.233 (0.25)	0.261 (0.43)
13	31	4404	0.420 (0.54)	0.120 (0.23)
14	12	3806	1.121 (1.00)	0.195 (0.21)
15	34	7141	0.352 (0.42)	0.714 (0.92)
16	19	2434	0.324 (0.25)	.
17	29	10245	0.565 (0.53)	0.552 (0.41)
18	28	3517	0.279 (0.28)	0.513 (0.46)
19	14	6434	0.396 (0.39)	1.091 (1.74)
20	34	1859	0.299 (0.51)	0.870 (1.30)
21	15	10017	0.316 (0.11)	0.817 (0.61)
22	26	8492	0.459 (0.36)	0.511 (0.38)
23	19	4095	0.684 (0.80)	0.187 (0.20)
24	19	9411	0.587 (0.94)	0.236 (0.31)
25	7	7677	.	1.713 (1.56)
27	10	1921	0.324 (0.19)	0.200 (0.20)
30	10	1196	.	0.527 (0.66)
51	18	1049	0.131 (0.06)	0.262 (0.38)
56	6	1499	.	0.651 (0.81)
69	10	2448	0.267 (0.36)	0.960 (1.26)
75	14	159	.	1.160 (2.77)
82	6	641	.	0.213 (0.26)
87	5	433	.	0.397 (0.15)
93	8	2355	.	0.995 (0.97)
106	14	71	.	0.099 (0.04)
111	3	84	.	1.114 (0.35)
119	6	380	.	0.583 (0.90)

the movements between Minnesota and Ontario, coordination of future management efforts among provincial, state, and federal agencies will be important.

Acknowledgments

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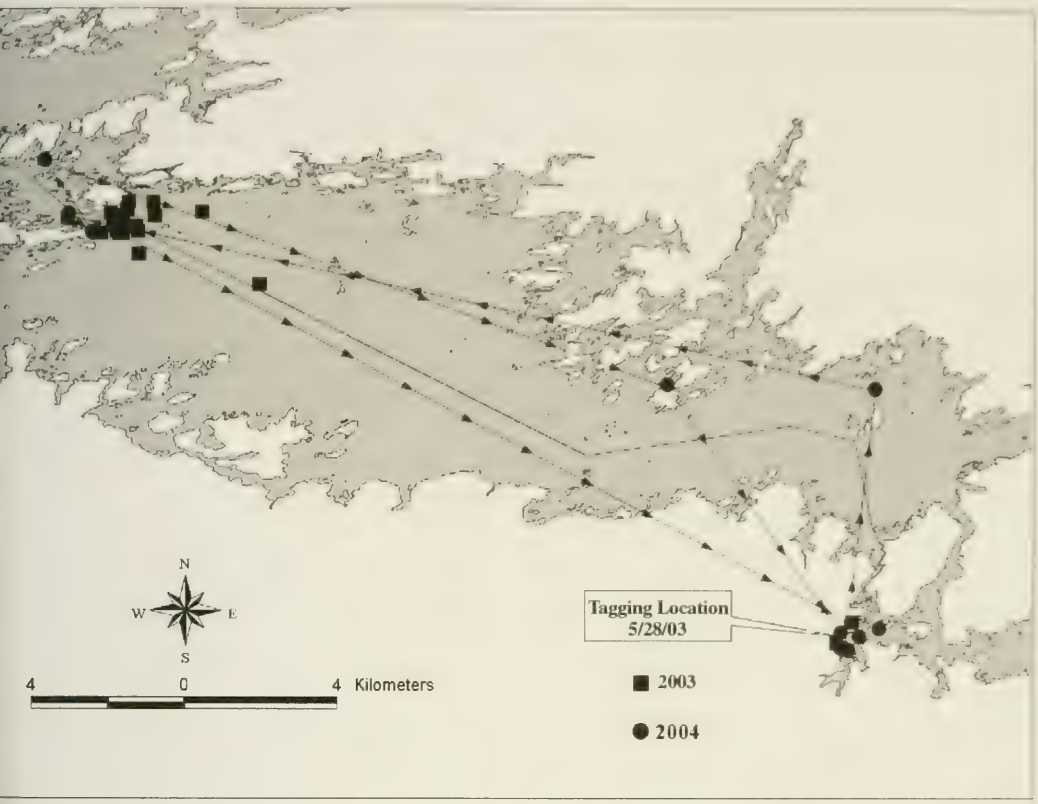

FIGURE 7. Distribution of locations for Lake Sturgeon number 15 in Rainy Lake, 2003 and 2004.

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Northern Range Expansion and Invasion by the Common Carp, *Cyprinus carpio*, of the Churchill River System in Manitoba

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Recent fisheries data from northern Manitoba indicates that the Common Carp (*Cyprinus carpio*) has extended the northern limit of its range. Additionally, it also appears that carp have invaded and established viable populations in the Manitoba portion of the Churchill River. Habitat degradation and altered flow regimes as result of hydroelectric development in northern Manitoba may have facilitated the expansion of carp in the region.

Key Words: Common Carp, *Cyprinus carpio*, exotic species, range expansion, invasion, habitat disturbance, Manitoba

The Common Carp (*Cyprinus carpio*) was introduced intentionally to Manitoba, Canada, when fish from Minnesota were stocked in the Assiniboine River watershed southeast of Brandon in 1886 (Stewart and Watkinson 2004). These early attempts at introduction failed, and carp only became established after populations from the northern U.S. entered the province through the Red River (Atton 1959). In fact, the Common Carp was largely unknown in Manitoba until 1938, when it was positively identified in the Red River near Rockport (Hinks 1943). Today, the Common Carp is found throughout most of the southern and central regions of the province, but particularly in the Red and Assiniboine rivers, and lakes Manitoba, Winnipeg, and Winnipegosis. Common Carp do not appear to have extended into the eastern portion of the province, likely due to the fact that they cannot easily migrate upstream in this region because of the many obstructions they would encounter (i.e., Beaver dams). Additionally, lakes in this portion of the province are characterized by rocky substrates and clear deep waters typical of the Precambrian Shield and do not provide suitable habitat for viable populations of the Common Carp.

Benthivorous fish such as the Common Carp can have profound effects in aquatic ecosystems by increasing turbidity through sediment resuspension while foraging and spawning (Breukelaar et al. 1994; Zambrano et al. 2001). Carp are known to uproot submerged macrophytes during spawning and accidentally consume them while foraging for benthic invertebrates (Wolterman 1990; Roberts et al. 1995; Lougheed et al. 1998; Zambrano and Hinojosa 1999). Sediment resuspension and excretion by carp can increase water column nutrient concentrations, thereby causing phytoplankton to flourish (Lamarra 1975; Breukelaar et al. 1994; King et al. 1997). A shading effect results from these blooms, further suppressing submerged macrophytes and creating an ecological feedback mechanism that perpetuates the turbid state (Scheffer 1998). Carp physically disturb the sediment-water interface and the algae associated with sediment. These algae play a major role in the stabilization of the bottom sediments (Taylor et al. 1998) and the regulation of nutrient fluxes across the sediment-water interface (Goldsborough and Robinson 1985; Carlton and Wetzel 1988; Woodruff et al. 1999). It is thought that many of the once clear, shallow lakes and wetlands in southern Manitoba have switched to the turbid state due to the loss of submerged macrophyte cover which, in turn, was caused by the proliferation of Common Carp (Badiou 2005).

Before 1940, carp were found only in the waters of the Red River (Figure 1a). After invading the province from the south, the Common Carp spread quickly throughout the Red and Assiniboine River watersheds prior to the 1950s and established themselves in the south basins of lakes Winnipeg and Manitoba (Figure 1b). However, the greatest range expansion occurred between 1950 and 1970 when carp were easily able to access the northern and western portions of the province after successfully invading Lake Winnipeg, Lake Manitoba, and Lake Winnipegosis, the largest lakes in the province (Figure 1c). Swain (1979) indicated that by 1976 the Common Carp was found in most large lakes and virtually all major rivers in Manitoba, with the exception of the Churchill River system.

A specimen collected from Split Lake (Figure 1d) in 1963 was considered to be the most northerly record for the distribution of carp in the world (McCrimmon 1968). These original reports stated that carp caught from Split Lake appeared emaciated and unhealthy. According to Atton (1959), cold summer temperatures prevented the carp from invading the Churchill River system. However, as shown in Figure 1d, the Common Carp has migrated northward through the Nelson River

system and, in the last decade, has become established in the Churchill River system according to carp production data spanning the period from 1970 to 2004.

On the Nelson River system, carp have become established in Split Lake where commercial catches (3–74 kg per year) have been reported starting in 1996. Fish monitoring studies for the Limestone Generating Station (C. Barth, personal communication) and the proposed Gull Generating Station (D. J. Pisiak, unpublished data) documented Common Carp in Stephens Lake and in the forebay of the Limestone Generating Station (Figure 1d). Furthermore, during the course of fish studies for the proposed Conawapa Generating Station, a large, approximately 4 kg, Common Carp was caught in a backwater area near the lower Limestone Rapids (P. Nelson, personal communication). This is the first report of Common Carp downstream of the Limestone Generating Station and the most northerly location documented for the Nelson River.

More important than the northward expansion of carp on the Nelson River system is the invasion of the Churchill River system in the last decade. Recent fisheries records for northern Manitoba provided by the Freshwater Fish Marketing Corporation indicate that the Common Carp is now established in and around the Churchill River system with commercial catches reported from Britton, Guthrie, Highrock, Loon, Sisipuk, and Southern Indian lakes (Figure 1d). Commercial catches in these lakes were much higher (range 8–1184 kg per year) relative to those from Split Lake on the Nelson River system. Carp were likely introduced into the Churchill River system from the Saskatchewan River system, either by fishers using them as bait or by birds that may have inoculated carp eggs from one system into the other. A thorough search of the primary literature and government documents revealed that Common Carp have not been reported in the Saskatchewan portion of the Churchill River. The fact that carp have not been reported in the Churchill River in Saskatchewan indicates that the transfer of the Common Carp between the Saskatchewan River and Churchill River systems must have occurred within the province of Manitoba in the vast wetland area that occurs between these two watersheds along the Manitoba/Saskatchewan border.

Based on the fact that carp were found in Split Lake as early as 1963, it is not surprising that they have continued to migrate northward through the Nelson River system. However, given the poor condition of carp in Split Lake in 1963, a change must have occurred, which has allowed them to persist in this system. The two basic habitat requirements necessary to sustain carp populations are: (1) a shallow marsh environment with abundant aquatic vegetation for spawning and, (2) an area of deep water where carp can overwinter (McCrimmon 1968). We hypothesize that the construction of the Kettle Generating Station in 1974 at the outlet of Stephens Lake on the Nelson River provided the necessary habitat requirements to allow the establishment and sustain viable populations of Common Carp in Split Lake and Stephens Lake. Construction of this generating station increased the size of Stephens Lake by 242 km^2 and resulted in the flooding of 192 km^2 of land (Environment Canada / Fisheries and Oceans 1992a). This created an extensive area of shallow marsh-like habitat where carp could spawn in the summer. This was the case in Ontario where Swee and McCrimmon (1966) reported that Lake St. Lawrence near Cornwall, formed as the result of flooding during hydroelectric development on the St. Lawrence River, provided ideal spawning habitat for the Common Carp. However, it was also noted that fluctuations in lake level associated with hydroelectric activities caused many of the eggs attached to vegetation to be exposed and destroyed. More importantly, the construction of the Kettle Generating Station, with a forebay head of 30 meters (Environment Canada / Fisheries and Oceans 1992a), created a deep basin with warmer profundal zone waters to which carp can escape during cold winter months.

The completion of the Churchill River Diversion in 1976 raised the water level in Southern Indian Lake by approximately 3 m and flooded 187 km^2 of surrounding land (Environment Canada / Fisheries and Oceans 1992a). Like the flooding experienced on Stephens Lake after the construction of the Kettle Generating Station, flooding on Southern Indian Lake would have also provided ideal spawning habitat for carp. The extensive flooding on Southern Indian Lake increased shoreline erosion and drastically increased suspended sediment concentrations in the lake from 5 $mg{\cdot}L^{-1}$, pre-impoundment, to 30-50 $mg{\cdot}L^{-1}$, post-impoundment (Environment Canada / Fisheries and Oceans 1992b). This anthropogenic increase in suspended sediments would have conferred a competitive advantage on carp which can feed more efficiently in highly turbid waters due to their superior olfactory senses, relative to sight-feeders (Panek 1987).

Water flows on the Churchill and Nelson river systems have been altered dramatically as a result of the Churchill River Diversion, which has diverted 80% of the flow from the Churchill River at Southern Indian Lake into the Nelson River system. Carp are found in large, slow-moving rivers as well as fast flowing streams (Panek 1987). Due to the ability of carp to inhabit waters of varying flow, the increased flow on the Nelson and decreased flow on the Churchill, as well as the increased variability in flows in both systems as a result of hydroelectric development, would also have conferred an advantage on the Common Carp relative to native fish that may be less tolerant of variations in flow regime.

Overall, it is not surprising that Common Carp are invading northern Manitoba in step with hydroelectric development, as many authors have demonstrated the link between anthropogenic habitat alteration and invadability of ecosystems (Moyle and Light 1996; Keith and James 1999; Byers 2002). Keith and James (1999) showed a positive correlation between the num-

FIGURE 1. Range expansion of the Common Carp (*Cyprinus carpio*) in Manitoba (A) prior to 1940, (B) prior to 1950, (C) prior to 1970, and (D) prior to 2000. Carp distributions prior to 1970 were estimated based on date of first occurrences reported in Swain (1979), while the range expansion between 1970 and 2000 was estimated from carp production data provided by Manitoba Conservation and the Freshwater Water Fish Marketing Corporation for the period from 1970 to 2000. Numbers in D indicate locations discussed in the text: (1) Split Lake, (2) Stephens Lake, (3) Limestone Generating Station, (4) Britton Lake, (5) Sisipuk Lake, (6) Guthrie Lake, (7) Highrock Lake, (8) Southern Indian Lake, (9) Loon Lake, (10) Churchill River Estuary, and (11) Nelson River Estuary.

ber of reservoirs and the number of introduced species in North American drainages. Given that the Common Carp has already been reported in subarctic regions (Lukin 1999) and is tolerant of a wide range of salinity levels (Lam and Sharma 1985) it is a matter of time before the populations of carp established on the Nelson and Churchill river systems reach the Churchill River and Nelson river estuaries.

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Diversity and Range of Amphibians of the Yukon Territory

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Four amphibian species occur in the Yukon: Western Toad (*Bufo boreas*; first verified record in 1961), the Boreal Chorus Frog (*Pseudacris maculata*, first record in 1995), the Columbia Spotted Frog (*Rana luteiventris*, first record in 1993), and the Wood Frog (*Rana sylvatica*; first record in 1933). The Western Toad is restricted to the Liard Basin in five geographically separated areas. Breeding sites have been located on the lower Coal River and vicinity. The Boreal Chorus Frog has been documented from a small area of the lower La Biche River valley near the Yukon-British Columbia-Northwest Territories border. The Columbia Spotted Frog occurs in two widely separated areas, at Bennett Lake in the southwest and in the Liard Basin in the southeast. The Wood Frog is widespread below treeline. Limited survey efforts continue to hinder our knowledge of amphibian distribution.

Key Words: *Bufo boreas*, Western Toad, *Pseudacris maculata*, Boreal Chorus Frog, *Rana luteiventris*, Columbia Spotted Frog, *Rana sylvatica*, Wood Frog, amphibian, Yukon, distribution.

Biological surveys began in the interior of the Yukon Territory in 1899 (Osgood and Bishop 1900); however, these were often directed at mammals and birds, and did not report amphibian observations. The earliest known amphibian records for the region are from Atlin (Slevin 1928; Western Toad and Wood Frog) and Bennett Lake, British Columbia (Logier 1932; Columbia Spotted Frog, formerly Western Spotted Frog). The first published report of amphibians in the Yukon was by Loomis and Jones (1953), who reported a Wood Frog collected at Dezadeash Lake in 1948 by the University of Kansas Museum of Natural History. Museum collections from the Canadian Museum of Nature (CMN) and the American Museum of Natural History (AMNH) date to 1933 and 1936, respectively. Logier and Toner (1961) report only the single locality record of Loomis and Jones (1953). Using an expanded database, including museum specimens and inferences from locality records in Alaska, the Northwest Territories and British Columbia, Martof (1970) shows an approximate range for the Wood Frog; although a large area with no data existed in the eastern and northern Yukon. The amphibian range maps in Stebbins (2003) were modified with information provided by BGS.

The Western Toad (*Bufo boreas*) was first observed in 1961 in the southeast Yukon (Cook 1977). The Columbia Spotted Frog was first observed in 1993 (Mennell 1997) in the southwest Yukon. There are no published records of the Boreal Chorus Frog or other species for the Yukon. All species of amphibians have been underrepresented in records due to the remoteness of breeding sites and lack of directed surveys. Several amphibian surveys and expert observations have been made since 1993 by the authors and others, and the data have remained unpublished. We typically used visual encounter surveys and dipnetting of terrestrial, semi-terrestrial (wetland) and aquatic habitats (Thoms et al. 1997). We review unpublished data, unpublished reports and museum collections to present an update on the amphibian species of the Yukon and their ranges. Anecdotal information on phenology and habitats is provided. Scientific and common names follow Collins and Taggart (2002).

Species Accounts

Western Toad (*Bufo boreas*)

Western Toads occur from south-coastal Alaska, through western Canada and the western United States to Baja California. Cook (1977) reported two museum specimens of the Western Toad from the Yukon. The Whitehorse specimen, collected in 1948, was verified in 1997 by F. Cook, who also verified the label in 2003 as collected by William Mason July 1-10. Mason was an entomologist and the date notation suggests a specimen taken in a pan or similar trap set for that period and contents preserved on the last date (F. Cook, personal communication). This specimen is here considered to be either an extra-limital stray or erroneously labelled, since the nearest confirmed breeding records of Western Toads are 100 km to the south in British Columbia on Bennett Lake (Slough 2004*; 17 km from the British Columbia-Yukon border) and on Tagish Lake (Mennell and Slough 1998*; 40 km from the border). A single adult was found in non-breeding habitat on Tagish Lake 9 km from the border (Mennell and Slough 1998*). All other records are from the Liard Basin in the southeast Yukon, where the Western Toad is now known from at least 11 populations in five geographically separated areas (Figure 1). These are summarized from west to east.

Two adult Western Toads were observed near a geothermal spring on the Meister River (60°17'N, 130°07'W) in 1988 (D. Mossop, personal communi-

cation). RLM searched this area in 2004 but did not observe Western Toads. A single adult was observed near Upper Liard (60°05'N, 128°58'W) in 2004 (C. Eckert, personal communication; verified from photographs).

At least six breeding populations of Western Toads occur in close proximity (within 16 km) on the lower Coal River and wetlands to the west. The most visited population and breeding site is the Coal River Springs (60°09'N, 127°26'W). G. Scotter collected two specimens in 1977 (CMN 17798-1 and -2), and at least six Western Toad records of adults and metamorphs were documented between 1982 and 2004 (B. Slough and L. Mennell, unpublished data; Slough 2005a*). Two breeding sites exist in spring marshes below the upper and lower springs. The temperature of the main source pool is 11°C, likely maintaining frost-free hibernating sites nearby. Other breeding sites occur in riparian floodplain backwater channels and ponds above the springs (60°11'N, 127°29'W), below the springs on an island in the Coal River (60°07'N, 127°24'W), and further downstream on the Coal River in a bedrock pool [60°08'N, 127°14'W] (J. Staniforth and J. Meikle, personal communication; L. Mennell, unpublished data; Slough 2005a*). Juvenile toads have also been observed in the chain of lakes southwest of the springs (60°14'N, 127°29'W) [B. Slough, unpublished data; Slough 2005a*] and in a tributary of the lakes (60°06'N, 127°32'W) [Slough 2005b*], suggesting the presence of breeding populations.

Cook (1977) reported a specimen collected in 1961 from North Toobally Lake (60°20'N, 126°15'W). An adult Western Toad was observed 23 km to the south near South Toobally Lake (60°08'N, 126°19'W) in 1996 (C. Eckert, H. Grunberg, P. Sinclair, personal communication; verified from photograph). A single adult Western Toad was observed on the lower Beaver River [60°02'N, 124°32'W] in 1997 (B. Bennett, V. Loewen, J. Staniforth, personal communication; verified from photograph). All of the Western Toad localities are low elevation sites with early deep snow accumulation. The snow cover likely prevents deep frost penetration and permits safe hibernation, as speculated by Cook (1977).

Western Toad breeding sites are predominantly shallow, silty areas on ponds, lakes and rivers. Adults are often encountered far from water in forests or meadows. Breeding dates in the Yukon are unknown; however, populations in northwestern British Columbia breed in late May (B. Slough and L. Mennell, unpublished data). A population in the Atlin Warm Springs, 20 km south of Atlin, breeds in late February-early March. Tadpoles have been observed on the Coal River in July, and tadpoles and metamorphs were observed there on 10 August 2004.

BOREAL CHORUS FROG *Pseudacris maculata*

While *Pseudacris maculata* is currently considered a distinct species following Platz (1989), it was formerly called *P. triseriata maculata* (and earlier *Pseudacris triseriata septentrionalis*). Recent phylogeographic studies of North American chorus frogs have shown that range limits and taxonomy of the *triseriata* complex may need revision (Moriarty and Cannatella 2004). The Boreal Chorus Frog ranges across much of central North America east of the continental divide, from the Northwest Territories to southern James Bay and south to Arizona and New Mexico. We present the first records of the Boreal Chorus Frog from the Yukon. Boreal Chorus Frog calls were identified at five natural wetlands and roadside/airstrip ditches along a 10 km section of road and airstrip in the lower La Biche River valley in the southeast Yukon (60°03'N 123°58'W to 60°08'N 124°03'W) between 8 and 17 June in 1995, 1997 and 1999 (Figure 1) [B. Bennett, C. Eckert, V. Loewen, P. Sinclair, J. Staniforth, personal communication; B. Slough, unpublished data]. BGS also identified Boreal Chorus Frog tadpoles there on 10 June 1999. Extensive surveys by the authors in southeastern Yukon in 2004 did not yield any further observations of the species. Matsuda et al. (2006) show the species 160 km to the southeast at Fort Nelson, British Columbia, and it occurs 125 km northeast at the junction of the South Nahanni and Liard rivers (Fournier 1998*).

COLUMBIA SPOTTED FROG *(Rana luteiventris)*

The Columbia Spotted Frog occurs between the Rocky Mountains and Coast Ranges from the Yukon to Utah and Nevada in the south. Mennell (1997) located two populations of Columbia Spotted Frogs adjacent to the West Arm of Bennett Lake in 1993, in a pond (60°05'N 135°01'W) and a beaver pond on a creek (60°01'N 135°12'W) [Figure 1]. Slough (2002) obtained single voucher specimens and preserved toe-tips (for phylogeographic studies, n=10 and 11, respectively) from the two ponds in 2001 (Slough et al. 2002*). A third population was found in a beaver pond in the same area (Slough 2002) [60°03'N 134°58'W] where a voucher specimen and six toe-tips were obtained; specimens are held at the Redpath Museum, McGill University [RM 3382, 3379 and 3381 for the three populations, respectively]. Additional Columbia Spotted Frog adults (n=7 in 4 sites) were observed within 2.5 km of Site 2 in apparent non-breeding habitats (i.e., early life-stages not observed) along the Partridge River to Bennett Lake (R. McClure, personal communication, verified from photograph; B. Slough and L. Mennell, unpublished data). These three breeding populations are the most northerly of a series of populations that extends into northwestern British Columbia (Matsuda et al. 2006, Mennell 1997; Mennell and Slough 1998*; Slough et al. 2002*).

In 2003, two adult Columbia Spotted Frogs were observed in Irons Creek Lake in the southeastern Yukon (60°00'N 127°05'W; P. Hovingh, personal communication to Yukon Fish and Wildlife Branch) (Figure 1). Several adults, juveniles and one egg mass were observed in 2004 and 2005 (Slough 2005b*). The long-

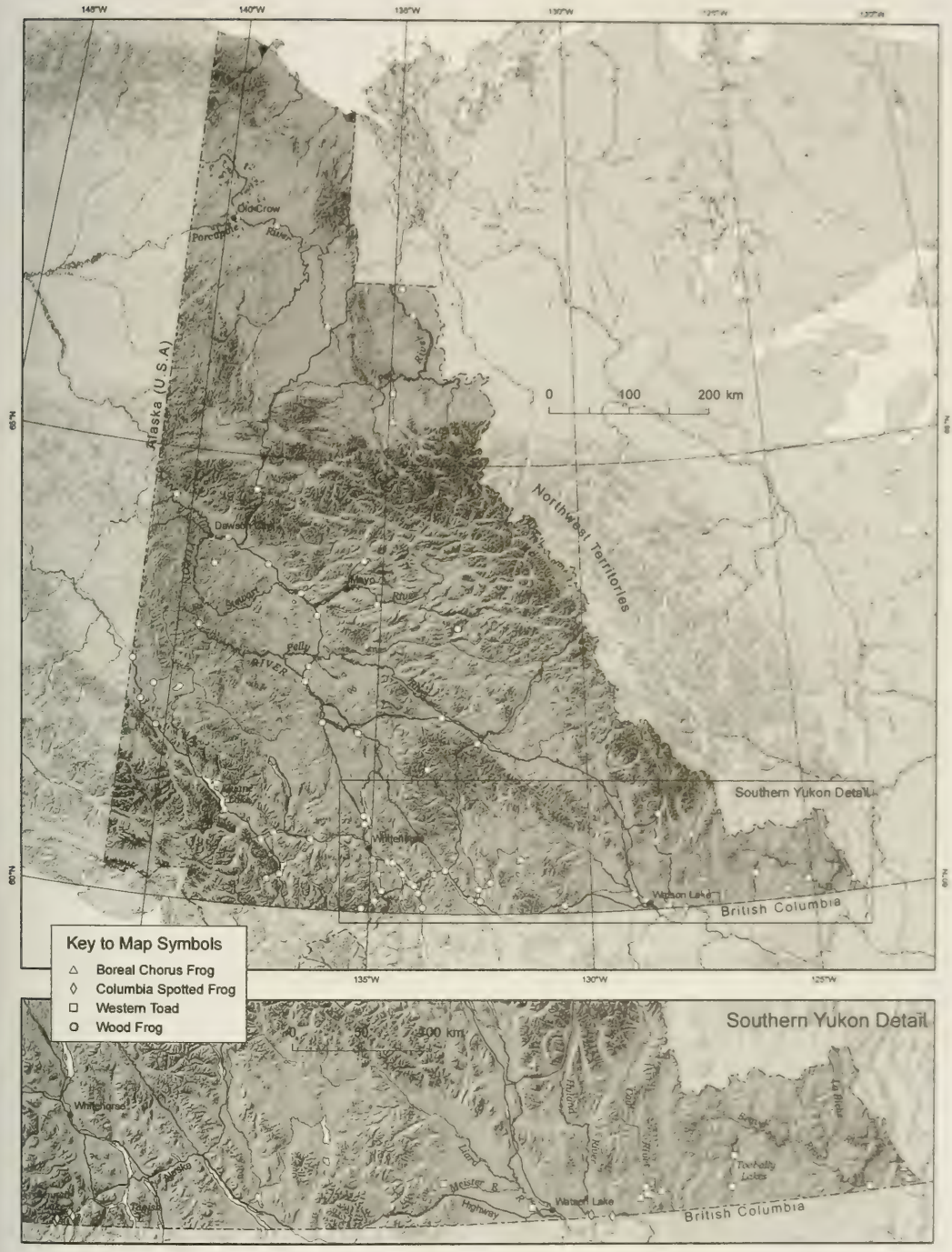

FIGURE 2. Distribution of amphibians in the Yukon. Refer to text for data sources. Shaded areas are mountain ranges.

term prospects of this population are unknown as this small lake has regularly been stocked with Rainbow Trout (*Oncorhynchus mykiss*) since 1990, with the latest stocking occurring in 2003 (D. Toews, personal communication). Rainbow trout are known to prey on Columbia Spotted Frog tadpoles and juveniles, which overwinter in lakes (Pilliod and Peterson 2000). Furthermore the heavily forested shoreline habitat is atypical for Columbia Spotted Frogs (Ovaska 1999*). The species has been observed only on human-altered shoreline which has been cleared of trees and graded into Irons Creek Lake, creating shallows. In 2004, RLM observed an adult Columbia Spotted Frog 15 km west of this site on an ox-bow channel of the Hyland River (60°01'N 127°12'W).

The Columbia Spotted Frog localities in the Liard Basin and Coast Mountain Cordillera are in areas with early deep snow accumulation which likely prevents thick ice formation and permits safe aquatic hibernation.

Columbia Spotted Frogs were noticeably abundant in and around pond outlets, where they were invariably perched at the waters edge. Breeding and transformation dates in the Yukon are unknown; however populations in nearby northwestern British Columbia have been observed extensively (Mennell 1998*; B. Slough, unpublished data). Breeding takes place on a single warm day from 18-22 May (six years of observations) in traditional shallow basins along the margins of ponds. Some of the ponds may be partially ice-covered with melting snow surrounding the ponds. They breed communally with up to 30 individuals congregating in a few square metres. Males begin calling above water over a larger area and finally call underwater as the aggregation consolidates and begins amplexis, leaving a mass of egg clutches unattached in shallow water. Breeding sites are occasionally compromised by falling water levels, leaving egg masses landlocked and stranded. Tadpoles are free-swimming in 14-16 days and metamorphs appear on pond edges throughout August (Mennell 1998*). Metamorphs have also been observed in late May, and tadpoles have been observed in mid-September at higher elevation ponds, suggesting that some tadpoles overwinter.

WOOD FROG *(Rana sylvatica)*

The Wood Frog ranges from northern Alaska and the Yukon through most of Canada below treeline east to the Atlantic and south to the Appalachian Mountains. Disjunct populations occur in several states south of this range. Numerous collections and observations reveal that Wood Frogs are common and abundant in wetlands across the Yukon below the arctic and alpine treeline (B. Slough, unpublished data) [Figure 1]. The most northerly location is Ney Khwi Vun ("Frogs in the Lake"), on the Old Crow Flats (68°01'N 140°05'W; Gray and Alt 2000*). Museum collections exist in the University of Kansas Museum of Natural History (n = 1), the American Museum of Natural History (n = 16), the Canadian Museum of Nature (n=56) and the Auke Bay Laboratory, Alaska Fisheries Science Center (Hodge 1976; n = 2). One of the museum specimens from mouth of Coal Creek (AMNH 44751) was originally misidentified as *Pseudacris septentrionalis* (now *P. maculata*) until verification as a Wood Frog in 1995 by L. S. Ford Curatorial Associate, AMNH (F. Cook, personal communication to P. Milligan). In July 2000, BGS obtained Wood Frog samples for phylogeographic studies (J. Irwin and J. Lee-Yaw, unpublished data); eight juveniles from Nogold Creek, west of Mayo (63°26'N 135°06'W), and 10 juveniles from south of Whitehorse (60°35'N 134°58'W). The CMN also has tissue from 11 adults and 25 juveniles from "Paddy's Pond", Whitehorse, July and August 1992 by Gerry Whitley.

The Wood Frog specimens and observations (Figure 1) document an extensive range for the species in the Yukon. Most observations are from road and river access corridors, and gaps in the range exist in inaccessible areas. We believe that the species occupies suitable habitats below treeline within these gaps. Furthermore, the distribution is continuous in areas of extensive wetlands such as the Whitehorse area, where only a small sample of locations was plotted. Yukon Wood Frogs were assigned to the Alaskan phenotype by Martof and Humphries (1959). While we have no data on most visible characters used to differentiate the types, there is a north-south gradient in the frequency occurrence of the mid-dorsal stripe, from approximately 100% in the north and central Yukon to 50% or less in the south.

Wood frogs breed in the Yukon as soon as shorelines become ice-free in late April-early May. They breed over a period of up to two weeks, they are frequently solitary breeders, and they do not necessarily use traditional breeding sites, but use any site with shallow water and sparse emergent grass or sedge vegetation. Egg masses are attached singly to grass or sedge stalks. Metamorphs move onto land throughout July. The most common Wood Frog breeding habitats are shallow, permanent and fishless ponds.

Neighbouring Species

Three species of salamanders occur near the southwestern Yukon, but have yet to be recorded there. The Long-toed Salamander (*Ambystoma macrodactylum*) ranges as far north as the Taku River (Hodge 1976; P. Milligan, personal communication; Mennell and Slough 1998*) and upstream to the junction of the Nakina and Sloko rivers (K. Heinemeyer, personal communication), 110 km from the British Columbia-Yukon border (observation not shown by Matsuda et al. 2006). The Northwestern Salamander (*Ambystoma gracile*) and Roughskin Newt (*Taricha granulosa*) occur in Southeast Alaska (MacDonald 2003), but they occupy Pacific coastal habitats not present in the Yukon.

Future Surveys

Dedicated amphibian surveys and expert observations have greatly increased our knowledge of the species and their ranges in the Yukon. We presented significant new observations of Western Toads, Columbia Spotted Frogs and Wood Frogs for the Yukon, and the first records of Boreal Chorus Frogs. Continued efforts should identify additional populations, their degree of isolation and habitat requirements; all necessary for conservation planning. The ranges of the Western Toad, Columbia Spotted Frog and Boreal Chorus Frog in the Yukon imply data deficiencies for these species in northern British Columbia. The Columbia Spotted Frog is common on Atlin Lake, south of Atlin (Slough et al. 2002*; not shown by Matsuda et al. 2006).

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Temporal Variability of Cetaceans near Halifax, Nova Scotia

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Simard, Peter, Jennifer L. Lawlor, and Shannon Gowans. 2006. Temporal variability of cetaceans near Halifax, Nova Scotia. Canadian Field-Naturalist 120(1): 93–99.

Annual and seasonal trends in sightings of coastal cetaceans near Halifax, Nova Scotia, were studied using observations from whale watching and dedicated research vessels from late spring to early fall of 1996 to 2005. Four species of cetaceans routinely used the area during the summer: White-beaked and Atlantic White-sided dolphins (*Lagenorhynchus albirostris* and *L. acutus*), Harbour Porpoises (*Phocoena phocoena*), and Minke Whales (*Balaenoptera acutorostrata*). The dolphin species were temporally separated, with White-beaked Dolphins being common earlier in the summer than White-sided Dolphins. White-sided Dolphins were unusually abundant in 1997, and were found in larger groups (mean = 46.5 ± 46.19 sd) than White-beaked Dolphins (mean = 9.1 ± 5.19 SD). The area also appears to be an important habitat for dolphin calves and juveniles of both species. Fin Whales (*B. physalus*) were commonly observed in relatively large groups in 1997, but were uncommon or absent in other years. Humpback Whales (*Megaptera novaeangliae*), Blue Whales (*B. musculus*) and North Atlantic Right Whales (*Eubalaena glacialis*) were uncommon in the area, although Humpback Whales were sighted frequently in 1997. Increased numbers of White-sided Dolphins, Fin and Humpback whales in 1997 may be explained by increased prey abundance and decreased sea-surface temperatures.

Key Words: White-beaked Dolphin, *Lagenorhynchus albirostris*, Atlantic White-sided Dolphin, *Lagenorhynchus acutus*, Harbour Porpoise, *Phocoena phocoena*, Minke Whale, *Balaenoptera acutorostrata*, Fin Whale, *Balaenoptera physalus*, Humpback Whale, *Megaptera novaeangliae*, seasonality, group size, calves, Nova Scotia.

In temperate ecosystems, it is common for cetaceans to exhibit seasonal and annual fluctuations in their distribution and abundance (e.g., Hooker et al. 1999). These fluctuations are thought to be a reflection of seasonal changes in the environment, such as sea surface temperature (e.g., Hooker et al. 1999) and prey distribution (e.g., Kenney et al. 1996). Monitoring highly mobile, top level predators such as cetaceans serves not only to identify their habitat use patterns and track their population sizes, but also to monitor the health of the overall marine ecosystem.

The area between Halifax and Mahone Bay, Nova Scotia, is habitat for several species of cetaceans. It is used extensively by the commercial fishing industry, commercial shipping (especially near Halifax Harbour) and recreational boaters, and it is being used increasingly for whale watching. Given the high potential for anthropogenic influences in the Halifax area, there is good reason to study and monitor cetaceans there.

Methods

Field Methods

Data were collected from 1996 to 2005, primarily from 1 June to 30 September. From 1996 to 1999, 12.6 m and 14 m whale watching vessels were used to make three 3-hour trips daily, weather permitting. In 2000 and 2001, an 8.5 m auxiliary sailing vessel was used, and in 2002 to 2005 a 4.2 m rigid inflatable boat was used. The latter two vessels were used only for research, and cruises in 2000 to 2005 were generally conducted only in weather conditions suitable for photo-identification. All surveys were limited to daylight hours and the area bounded by approximately 44°19' to 44°38'N latitude and 63°15' to 64°10'W longitude (Figure 1). The path of all vessels was opportunistic, based on where cetaceans were previously sighted. In 1996, only date, time, species, group size and the presence of calves and juveniles were recorded. In subsequent years, latitude and longitude positions were recorded (using GPS) for hourly search effort and species positions and photo-identification data were collected. Only those sightings identified to species level were included in analysis.

Animals were classified as adults, juveniles or calves. For odontocetes, first year calves were identified by having a length of <50% of adult body length, while juveniles were identified by having 50% – 70% of adult body length (Reeves et al. 1999; Lien et al. 2001; Bjørge and Tolley 2002). The identification of calves was often facilitated by their position near an adult, with younger calves displaying "chin-slap" surfacings, and in the case of neonatal calves, by fetal folds and bent-over dorsal fins (Weinrich et al. 2001). For mysticetes, calves were identified by having a length of

<40%, and juveniles by having a length of 40% – 60% of adult body length (Aguilar 2002; Clapham 2002; Perrin and Brownell 2002).

Over the ten-year study period, changes in methodology introduced several biases to our data. Data collected from the whale watching boats (1996-1999) were particularly problematic as the boat returned several times per day with new passengers to the same area where cetaceans had previously been sighted, potentially causing groups to be double-sampled and introducing a positive bias to calculations of hourly sighting rates. Cetacean encounters on the whale watching vessels were typically shorter in duration, and therefore a larger proportion of time was spent searching for new groups, introducing another potentially positive bias. However, the whale watching vessels were more likely to operate in inclement weather than the research vessels, which should negatively bias the sighting data. Larger groups were preferred on whale watching cruises, positively biasing group sizes. Vessel cruising speed also varied greatly in the nine year study period (ranging from 5 to 15 knots). These differences in survey speed changed our spatial sampling greatly, and therefore likely affected the sighting data. The height of observers above the sea surface also varied greatly, from a minimum 1.25 m to a maximum 5 m. Search effort varied greatly between different years and months, and as a result time periods with low effort may have had unreliable sighting rates (see Table 1a and 1b).

Calculation of Sighting Indices

Because of these biases, regular group sighting rates (sightings per hour) would not be directly comparable. Therefore, the data were restricted in order to calculate a "sighting index" for each species per year and per month. Potential positive biases from repeated sampling of the same cetaceans throughout the day were eliminated by daily scoring each species as present or absent. This restriction also reduces biases introduced from differences in vessel speed, and time spent searching vs. time spent with groups of cetaceans. Calculated sighting indices could range from a maximum of 1.0 (sightings occurring every day of field effort) to 0.0 (no sightings). In order to determine if weather significantly affected sighting rates, the sighting rates during good weather and bad weather were subjected to a chi-squared test. Good weather was defined as visibility ≥ 1 km, wind ≤ Beaufort 3 (≤ ≈ 19 km/hr), wave height ≤ 0.75 m, and swells ≤ 1.5 m. Results from this test indicate that sighting rates were significantly lower in poor weather ($\chi^2 = 0.9999$, df = 5, $0.025<P<0.05$). Therefore, in order to reduce bias due to weather conditions, only sightings during good weather were included in analysis. Consequently, the sighting index was calculated as the proportion of good weather days each species was observed, and serves as an indicator of relative abundance. Data from 1996 and 2000 were not included in the analysis, as the environmental data were not collected frequently enough to determine if specific sightings occurred during good weather. In addition, any year or month in which the effort was less than or equal to five days and any species with less than or equal to 10 sightings in total were omitted from analysis as results from these would likely be unreliable (Table 1).

FIGURE 1. Location of study area.

Analysis

Chi-squared tests were used to test the null hypothesis that monthly and yearly sightings were random. Group sizes and the proportions of groups with calves, juveniles and total sub-adults (calves + juveniles) were also calculated for all species observed more than 10 times. Data were restricted to one randomly selected sighting per day in order to reduce biases caused by repeated sightings of the same group and by selection for larger groups by the whale watching vessels. In addition, these calculations were conducted only on sightings which lasted five minutes or longer, as it was difficult to accurately estimate group size and presence of sub-adults during shorter encounters. Group sizes and the proportion of groups with calves and juveniles were calculated both for all selected sightings and for selected sightings which occurred during good weather conditions. As the differences in the results of these two methods were negligible, the full data set was used for analysis of group composition and size.

Results

Between 1996 and 2005, eight species of cetaceans were sighted during 1715 hours (309 days) in the field.

TABLE 1. Search effort and number of sightings using full data set (a) for year and (b) for month (pooled across years).

(a)	Effort in hours (days)		White-beaked Dolphin	White-sided Dolphin	Harbour Porpoise	Minke Whale	Fin Whale	Hump-back Whale	Blue Whale	Northern Right Whale	Total
1996	477	(79)	25	28	14	133	0	0	0	0	200
1997	487	(60)	16	78	12	117	110	52	0	0	385
1998	47	(7)	4	2	4	23	1	0	0	0	34
1999	304	(51)	19	5	23	74	0	0	0	0	121
2000	31	(7)	0	1	0	1	0	0	0	0	2
2001	31	(5)	2	0	1	3	0	0	0	0	6
2002	87	(23)	11	6	13	8	2	0	1	0	41
2003	139	(45)	13	8	15	37	4	0	0	0	77
2004	54	(15)	13	1	7	17	0	0	0	2	40
2005	58	(17)	5	1	13	6	0	1	1	0	27
Total	1715	(309)	108	130	102	419	117	53	2	2	933

(b)	Effort in hours (days)		White-beaked Dolphin	White-sided Dolphin	Harbour Porpoise	Minke Whale	Fin Whale	Hump-back Whale	Blue Whale	Northern right Whale	Total
April	4	(2)	0	0	1	0	0	0	0	0	1
May	66	(23)	5	0	6	33	0	0	0	0	44
June	361	(79)	48	1	31	45	7	2	0	2	127
July	544	(87)	44	34	39	93	33	12	1	0	242
August	494	(74)	11	76	18	215	55	33	1	0	405
September	217	(39)	0	16	7	29	17	5	0	0	74
October	24	(4)	0	3	0	4	5	1	0	0	13
November	5	(1)	0	0	0	0	0	0	0	0	0
Total	1715	(309)	108	130	102	419	117	53	2	2	933

White-beaked Dolphins (*Lagenorhynchus albirostris*), Atlantic White-sided Dolphins (*L. acutus*; henceforth referred to as White-sided Dolphins), Harbour Porpoises (*Phocoena phocoena*) and Minke Whales (*Balaenoptera acutorostrata*) were observed in most years although annual and seasonal variations were observed (Tables 1a and 1b). Fin Whales (*B. physalus*) and Humpback Whales (*Megaptera novaeangliae*) were observed occasionally, and Blue Whales (*B. musculus*) and North Atlantic Right Whales (*Eubalaena glacialis*) were observed only rarely (Tables 1a and 1b).

Annual sighting indices of White-beaked and White-sided dolphins, Harbour Porpoises, Minke Whales, Fin Whales and Humpback Whales were significantly different from random (Table 2a). White-beaked Dolphins were sighted more frequently in 2003 and 2004 and White-sided Dolphins were sighted more frequently in 1997 and 2002. Harbour Porpoises were observed more commonly in 2002 and 2005, and Minke Whales were observed more commonly in 1999 and 2004. Fin and Humpback whales were sighted more frequently in 1997.

Monthly sightings of White-beaked and White-sided dolphins, Fin Whales and Humpback Whales were significantly different from random (Table 2b). White-beaked Dolphins were observed more frequently than expected early in the summer (June and July), while White-sided Dolphins were sighted more frequently than expected late in the summer (July through September). Fin Whales were observed more frequently than expected in August and September, and Humpback Whales were seen more frequently than expected in August. Monthly sightings did not differ significantly for Harbour Porpoises and Minke Whales.

White-sided Dolphins were found to have the largest mean group size of 46.5 (± 46.19 SD), and the highest proportion of groups with calves (0.354). Harbour Porpoises had the smallest group size of the odontocetes (mean = 2.7 ± 1.78 SD). Mysticete group sizes were typically smaller than odontocetes and only a few juveniles and no calves were observed (Table 3).

Discussion

White-beaked and White-sided Dolphins, Harbour Porpoises and Minke Whales were found in all years in which more than seven days were spent in the field (Table 1a). This suggests that the Halifax area was an important summer habitat for these species, while Fin Whales, Humpback Whales, Blue Whales and North Atlantic Right Whales were occasional visitors. Although some significant temporal variability found in this study cannot be directly explained, several interesting trends were noticed.

Annual Variation

White-sided Dolphins were unusually abundant in 1997, along with Fin and Humpback whales (Table

TABLE 2. Effort and number of presence/absence sightings using data set restricted as outlined in methods, (a) for year and (b) for month (pooled across years). Sighting indices (proportion of good weather days each species seen) shown in brackets. "*" indicates non-random distribution ($P<0.005$).

(a)	Effort in days	White-beaked Dolphin	White-sided Dolphin	Harbour Porpoise	Minke Whale	Fin Whale	Hump-back Whale
1997	40	9* (0.225)	20* (0.500)	8* (0.200)	27* (0.675)	27* (0.675)	14* (0.350)
1999	33	9* (0.273)	2* (0.061)	11* (0.333)	27* (0.818)	0*	0*
2002	11	3* (0.273)	3* (0.273)	7* (0.636)	6* (0.545)	1* (0.091)	0*
2003	25	8* (0.320)	2* (0.080)	9* (0.360)	14* (0.560)	3* (0.120)	0*
2004	8	6* (0.750)	1* (0.125)	2* (0.250)	6* (0.750)	0*	0*
2005	17	4* (0.235)	1* (0.059)	9* (0.529)	5* (0.294)	0*	1* (0.059)
Total	134	39 (0.291)	29 (0.216)	46 (0.343)	85 (0.634)	31 (0.231)	15 (0.112)
Chi-squared		$\chi^2=0.2444$ df = 5 $P<0.005$	$\chi^2=0.0003$ df = 5 $P<0.005$	$\chi^2=0.2138$ df = 5 $P<0.005$	$\chi^2=0.3592$ df = 5 $P<0.005$	$\chi^2=1.575\times10^{-9}$ df = 5 $P<0.005$	$\chi^2=2.026\times10^{-5}$ df = 5 $P<0.005$

(b)	Effort in days	White-beaked Dolphin	White-sided Dolphin	Harbour Porpoise	Minke Whale	Fin Whale	Hump-back Whale
May	13	3* (0.231)	0*	3 (0.231)	11 (0.846)	0*	0*
June	39	20* (0.513)	0*	15 (0.385)	20 (0.513)	2* (0.051)	1* (0.026)
July	47	16* (0.340)	11* (0.234)	18 (0.383)	26 (0.553)	9* (0.191)	4* (0.085)
August	29	2* (0.069)	14* (0.483)	8 (0.276)	25 (0.862)	12* (0.414)	9* (0.310)
September	10	0*	4* (0.400)	3 (0.300)	6 (0.600)	7* (0.700)	1* (0.100)
Total	138	41 (0.297)	29 (0.210)	47 (0.341)	88 (0.638)	30 (0.217)	15 (0.109)
Chi-squared		$\chi^2=0.0055$ df = 4 $P<0.005$	$\chi^2=0.0001$ df = 4 $P<0.005$	$\chi^2=0.8553$ df = 4 $0.05<P<0.1$	$\chi^2=0.3220$ df = 4 $0.01<P<0.025$	$\chi^2=8.837\times10^{-5}$ df = 4 $P<0.005$	$\chi^2=0.0047$ df = 4 $P<0.005$

2a). Several ecological correlates may explain the increases in these three species. Sea surface temperatures for Halifax Harbour were significantly lower in 1997 than in 1998 and 1999 (MANOVA p = 0.002 daily minimum, $P < 0.001$ daily maximum; Ocean Data Inventory Database, Department of Fisheries and Oceans Canada). In addition, Coakes et al. (2005) attributed the abundance of Fin Whales in the study area to a local increase in Herring (*Clupea harengus*), Sandlance (*Ammodytes americanus*) and euphausiids (possibly *Meganyctiphanes norvegica*). These species are also potential prey items of Humpback Whales (Kenney et al. 1996), and White-sided Dolphins are known to prey upon Herring and Sandlance (Reeves et al. 1999). In 1997, we observed mixed feeding aggregations containing all three species, which has also been observed in the Gulf of Maine (see Kenney et al. 1996).

Seasonal Variation

The most noticeable trend in the monthly sightings was the temporal differences in the observations of White-beaked and White-sided dolphins (Table 2b). White-beaked Dolphins were seen more often than expected in early summer and were rarely observed in August. Even within the full data set, this species was not observed after August (Table 1b). This observation may be related to water temperature, as White-beaked Dolphins appear to prefer colder water (Lien et al. 2001). However, the species was less commonly observed in 1997 when water temperatures were lower (Table 2a). The seasonal movements of White-beaked Dolphins are not well understood. Large numbers occasionally become ice-entrapped in Newfoundland in February and March (Hai et al. 1996), they are seen further offshore on Grand Bank in May and June (Whitehead and Glass 1985), and they occur along the coast of Labrador from late June to at least August (Alling and Whitehead 1987). Since the 1970s, the species has been rare in the Gulf of Maine (Kenney et al. 1996), although several recent sightings and strandings in the Bay of Fundy (personal observation) and the southern Gulf of Maine (Waring et al. 2004) suggest a possible return of White-beaked Dolphins to these portions of their historical range. They also appear to be rare in offshore Nova Scotian waters (Hooker et al. 1999; Lucas and Hooker 2000). Although these observations suggest that the White-beaked Dolphins in our study area may winter in the Gulf of St. Lawrence and disperse into other areas in the spring, an offshore or more southerly wintering ground cannot be ruled out (Lien et al. 2001), and different populations may have different migratory patterns.

In contrast to the White-beaked Dolphins, White-sided Dolphins appear to prefer the later part of the season; first seen in July, commonly observed in August and September, and still observed in October (Table 1b). This seasonal trend is similar to observations in

TABLE 3. Mean group sizes and proportion of Dolphin groups with calves present and with any sub-adult present.

	White-beaked Dolphin	White-sided Dolphin	Harbour Porpoise	Minke Whale	Fin Whale	Humpback Whale
Group Size	9.1	46.5	2.7	1.8	5.9	1.6
Range	2-20	5-250	1-6	1-4	1-20	1-4
n	44	48	12	84	43	24
SD	5.19	46.19	1.78	0.95	4.43	0.83
Groups with calves	7	17	2	0	0	0
(and proportion)	(0.159)	(0.354)	(0.167)			
Groups with juveniles	13	5	0	2	1	0
(and proportion)	(0.295)	(0.104)		(0.025)	(0.023)	
Groups with any	20	17	2	2	1	0
sub-adult (and proportion)	(0.455)	(0.354)	(0.167)	(0.025)	(0.023)	

the Gulf of St. Lawrence (Kingsley and Reeves 1998). However, in offshore areas of Nova Scotia the trend is reversed, and White-sided Dolphins are more common in the early summer (Hooker et al. 1999). This suggests a potential inshore-offshore migration for White-sided Dolphins in Nova Scotian waters. A similar migration has been suggested for the Gulf of Maine (Kenney et al. 1996). An alternate explanation is the existence of distinct coastal and offshore populations, each with its own migratory pattern, as seen in Common Bottlenose Dolphins (*Tursiops truncatus*; Wells and Scott 1999). However, as White-sided Dolphins are observed in April in the Gulf of Maine (Weinrich et al. 2001), the dolphins observed in our study area could also originate from further south.

The seasonal trends observed in the two dolphin species partially explain variations in annual sightings. For example, in 2000 White-beaked Dolphins were not observed (Table 1a). However, the first day of field work was not until late July, reducing the probability of observing the species that year.

In all years, temporal separation of the two dolphin species was observed, and they were rarely seen on the same day, with only one mixed group observed in the ten-year study period. Similar observations of temporal separation have been observed between White-sided Dolphins and Short-beaked Common Dolphins (*Delphinus delphis*; Gowans and Whitehead 1995), and between Common Bottlenose and Dusky dolphins (*Lagenorhynchus obscurus;* Würsig and Würsig 1980). This temporal separation could be due to seasonal changes in environmental or ecological conditions. Over a larger time scale, changes in water temperature and preferred prey species were thought to explain an increase in White-sided Dolphin abundance and a decrease in White-beaked Dolphin abundance in the Gulf of Maine (Kenney et al. 1996). However, some overlap in feeding ecology is possible (Northridge et al. 1997), and temporal separation may be a means of reducing competition by partitioning resources (Roughgarden 1976). In this case, a competitive exclusion relationship may exist, as suggested by Kingsley and Reeves (1998) for White-beaked and White-sided dolphin populations in the Gulf of St. Lawrence.

Fin Whales were seen more frequently than expected in August and September, while Humpback Whales were seen more frequently in August (Table 2b). These results are generally consistent with the migratory patterns of Humpback and Fin Whales (Aguilar 2002; Clapham 2002). Harbour Porpoises and Minke Whales showed no significant seasonality, suggesting that these species may be present in the study area for a longer season.

The temporal sighting patterns observed in this study were compared with stranding data from the Marine Animal Response Society of Nova Scotia (T. Wimmer, unpublished data). All species observed in this study stranded at least once in the study area between 1996 and 2004, with the exception of the rarely observed Humpback, Blue and North Atlantic Right whales. Several species that were not observed alive did strand in our study area between 1996 and 2004: Common Bottlenose Dolphin, Pygmy Sperm Whale (*Kogia breviceps*), Pilot Whale (likely Long-finned, *Globicephala melas*) and Sei Whale (*B. borealis*; although two Sei Whales were tentatively identified in the study area in August 1997). Most strandings occurred in July and August both within the study area and in the surrounding areas, months when cetaceans were most commonly observed at sea (Table 2b), although search effort for strandings was also highest in the summer. No strandings occurred in the study area from January to March, although search effort during these months was low. The only species that stranded in the study area late in the year (October – December) were White-sided Dolphins, Minke Whales and Fin Whales. We also observed these species at sea in the late summer and fall (Table 1b and 2b). Fin and Minke Whales have also been observed at sea in the study area during the winter (personal observation).

Group Sizes

White-beaked Dolphins were commonly found in groups of 10-20 animals in the western Atlantic (Lien et al. 2001), and the observed group size in this study

(mean = 9.1; Table 3) was similar to that found in the Gulf of St. Lawrence (aerial surveys, mean = 8.65; Kingsley and Reeves 1998). For White-sided Dolphins, the observed group size (mean = 46.5; Table 3) was similar to that reported in the Gulf of Maine (mean = 52; Weinrich et al. 2001). These group sizes were higher than those observed in the Gulf of St. Lawrence (mean = 8.25; Kingsley and Reeves 1998) and in offshore areas of Nova Scotia (mean = 8.8, Hooker et al. 1999). These observations support the idea of a seasonal migration into our study area from the Gulf of Maine, and/or ecological similarities between the two areas. However, group sizes were unusually high in 1997, and group sizes since 1997 have been smaller (mean = 32.3 ± 38.96 SD), also supporting the hypothesis that feeding conditions were unusually good in 1997. Harbour Porpoise group size (mean = 2.7, Table 3) was similar to other observations (e.g., mean = 2.42; Kingsley and Reeves 1998).

The group size found for Fin Whales (mean = 5.9; Table 3) was larger than many other studies in the western Atlantic (e.g., Gulf of St. Lawrence mean = 1.89; Kingsley and Reeves 1998, offshore Nova Scotia mean = 1.3; Hooker et al. 1999). The larger mean group size in this study may be due to the whale watching vessel having selected for larger groups. Consequently, smaller groups were likely omitted from our analysis as they often fell below the five minute threshold. A similar bias was discussed by Bérubé et al. (2001), who selected for larger groups of Fin Whales in the Gulf of St. Lawrence and found a mean group size of 5.89. Since 1997, fin whales were found in smaller groups (mean = 2.3 ± 1.89 SD), as was more common in other areas, again suggesting that our observations of larger group sizes were likely linked to high prey abundance in 1997. Group sizes for Minke and Humpback whales (mean = 1.8 and 1.6, respectively; Table 3) were typical for these species (e.g., Kingsley and Reeves 1998).

Calf and Juvenile Presence

Calves and juveniles were commonly observed in groups of White-beaked and White-sided dolphins (Table 3), consistent with the calving seasons for these species (Reeves et al. 1999; Lien et al. 2001). Given that dolphins have long juvenile stages relative to the time spent as yearling calves, it is not unexpected that more White-beaked Dolphin groups contain juveniles than calves (Table 3). The presence of two neonatal calves (identified by bent dorsal fins) in June indicates that the area at least occasionally serves as a calving ground for this species. White-sided Dolphins had a much higher proportion of groups with calves (35.4%). Young calves in "echelon position" were commonly seen in this species, and several calves with fetal folds have been observed in July and August. This suggests that these dolphins are in the study area for the peak of their calving season, and that the study area is an important nursery area for this species. White-sided Dolphin calves were less common than in the Gulf of Maine, where 41.4% of all groups contained calves, and 51.5% to 56% of groups contained calves between July and September (Weinrich et al. 2001). Far fewer groups in our study area contain juveniles (10.4%) than calves, supporting the hypothesis that juvenile White-sided Dolphins are segregated from other age classes, as suggested by Sergeant et al. (1980). Harbour Porpoise calves were observed far less frequently (16.7%; Table 3) than in the Bay of Fundy (63%; Gaskin and Watson 1985). This could be due in part to differences in research focus and methodology, and that our study area is more exposed, potentially making detection more difficult. Baleen whale sub-adults were rare during the study period (Table 3) and difficult to identify as the young were frequently far from adults. The scarcity of young calves of these species is consistent with their rapid body growth rates and what is known of their migration and calving patterns (Aguilar 2002; Clapham 2002; Perrin and Brownell 2002).

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Winter Habitat Use by American Marten, *Martes americana*, in Western Alberta Boreal Forests

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Although the American Marten (*Martes americana*) is found in most forest regions of Alberta, little is known about its choice of winter habitats. This study investigated winter habitat use by American Marten in Weyerhaeuser's Grande Prairie Forest Management Area (FMA) using snowtracking along 128.2 km of seismic lines inventoried in winters 1999, 2002, and 2005 with snowmobiles. American Marten tracks ($n = 44$) occurred significantly less frequently than expected ($P < 0.001$) in immature/young pole stands, but more frequently than expected ($P < 0.02$) in mature/old growth mixedwood stands. American Martens apparently used young forests, and mature/old coniferous and deciduous stands, according to their availability. Forest development plans should be developed locally to retain late successional forests that meet the winter habitat requirements of American Marten.

Key Words: American Marten, *Martes americana,* forest management, winter habitat, Alberta.

Studies in coniferous forests of western North America suggest that American Martens (*Martes americana*) prefer late successional stands with vertical and horizontal structural complexity (Proulx et al. 2004). Koehler and Hornocker (1977) in Idaho, Campbell (1979) in Wyoming, and Koehler et al. (1990) in Washington reported that the highest level of American Marten activity was associated with mature Englemann Spruce – Subalpine Fir (*Picea engelmannii – Abies lasiocarpa*) forest type. In California, Spencer et al. (1983) concluded that optimal habitat for American Marten was extensive late successional forest. In British Columbia, most studies reported that American Martens used late successional coniferous forests. In the Sub-boreal Spruce Biogeoclimatic Zone, Lofroth (1993) found that American Martens preferentially included mature to old-growth forests in their home ranges. Proulx et al. (2005) described American Marten winter habitats in this biogeoclimatic zone as late-successional, circum-mesic stands with relatively high canopy closure and/or basal area. In the Boreal White and Black Spruce Biogeoclimatic Zone of northeastern British Columbia, Therrien (2002) found that American Martens preferred mature mixedwood forests. On the other hand, Poole et al. (2004) found that American Martens preferentially used mature coniferous forests but otherwise appeared to use all forested stands relative to their availability, including extensive deciduous and mixedwood stands <40 years of age.

Although American Marten is an important furbearer found in most forest regions of Alberta, little is known about its choice of winter habitats. I investigated winter habitat use by American Marten in Weyerhaeuser's Grande Prairie Forest Management Area (FMA) using snowtracking. On the basis of previous studies conducted in western North America, I hypothesized that American Marten tracks would be found mainly in late-successional forests.

Study Area

The Grande Prairie FMA (55°11'N, 118°53'W) is a 1 145 600-ha area located in northwestern Alberta, along the British Columbia border (Figure 1). Relief varies greatly, from undulating in the north and northeastern portions of the FMA, to mountainous areas, with elevations exceeding 1350 m in the south and southwest. Half of the FMA has a subhumid, continental climate with short, cool summers and long, cold winters (Alberta Government 1999*). The southern and southwestern half of the FMA has a subalpine climate, with below freezing temperatures occurring in all months and winter precipitation often exceeding 200 cm of snowfall (Alberta Government 1999*). The FMA is located within the Boreal vegetation zone, characterized by Engelmann Spruce, White Spruce (*Picea glauca*), Black Spruce (*Picea mariana*), Subalpine Fir, Balsam Fir (*Abies balsamea),* Lodgepole Pine *(Pinus contorta)*, and Trembling Aspen (*Populus tremuloides*) in both pure and mixed stands (Looman and Best 1987; Alberta Government 1999*).

Methods

Snowtracking was conducted from 4 to 16 January 1999 (15 transects ranging in length from 0.2 to 8.7 km; total: 41.1 km), 12 to 27 February 2002 (14 transects ranging in length from 0.5 to 7.1 km; total: 36 km), and 20 January to 9 February 2005 (25 transects ranging in length from 0.8 to 4.3 km; total: 51.2 km). The number and length of inventory transects varied according to accessibility, safety, and environmental conditions. These corresponded to randomly selected 6-m wide seismic lines distributed across the FMA. The

FIGURE 1. Location of Weyerhaeuser's Grande Prairie Forest Management Area (FMA) and inventoried regions in western Alberta.

same regions were investigated during the three inventories (Figure 1). A few seismic lines were used repeatedly over the years. In most cases, however, this was not possible because of access problems (overgrown vegetation, inappropriate snow conditions, or interfering gas exploration or logging activities), or transformation of seismic lines into roads or pipelines. Habitat type classification along inventory transects was based on Proulx and Kariz (2005) (Table 1).

Transects were traversed by snowmobiles (<10 km/h). We recorded only tracks that were well-defined and judged to be fresh; i.e., less than 24 h old (subjective assessment based on the experience of the researcher). Due to the similarity between Fisher (*Martes pennanti*) and American Marten footprints (Halfpenny et al. 1995), when mustelid tracks were encountered, they were investigated on both sides of transects and within forest stands to find the best tracks available. The combination of footprint (pattern and size, presence absence of toe pad prints) and trail (gait, distance between jumps, and dragging of the feet) characteristics were used to identify tracks (Murie 1975; Rezendes 1992; Halfpenny et al. 1995). Fisher tracks are usually larger and farther apart, although the footprints of female Fishers and male American Martens may be of similar size. In winter, the undersurface of American Martens' feet is heavily covered with hair and toe pads do not show (Murie 1975; Rezendes 1992). The undersurface of Fishers' feet has sparse hair, and pads show well in clear prints (Halfpenny et al. 1995). Compared to American Martens, Fishers tend to walk more, leave straight trails, create troughs when walking in soft snow, drag their feet, and leave tail drag-marks in the snow (de Vos 1951; Raine 1983). Compared to American Martens, Fishers seldom tunnel under the snow (Halfpenny et al. 1995). Scats found on trails were also used

TABLE 1. Habitat types used in the study of American Marten winter habitat use in 1999, 2002, and 2005 in Weyerhaeuser's Grande Prairie Forest Management Area, Alberta (after Proulx and Kariz 2005).

Forest type	Characteristics
Deciduous	Crown closure ≥ 10%, deciduous species > 75%.
Coniferous	Crown closure ≥ 10%, coniferous species > 75%.
Mixedwood	Crown closure ≥ 10%, neither type > 75%
Habitat type	**Description**
Immature-Pole	0-40 years old stands. Open areas and new stands. Pole stands are thick stands of trees (7.5 to 12.4 cm diameter at breast height), usually with little understory.
Young	40-80 year-old forests. Achievement of dominance by some trees and death of other trees leads to reduced competition that allows understory plants to become established. The forest canopy has begun differentiation into distinct layers. Vigorous growth and a more open and multi-storied stand than in the pole stage.
Mature-old	≥ 81 years old late successional stands consisting mostly of mature stands with even canopy of trees, with or without coarse woody debris down and leaning logs. A few old stands with tall and large canopy trees, canopy gaps, large snags, large downed woody debris, and developed understories. A second cycle of shade tolerant trees may have become established.

to identify animals. When encountering animals, footprints and trails were studied to ascertain criteria used to differentiate American Marten from Fisher.

Autocorrelation may occur during analysis of track survey data because of the uncertainty in whether one or more animals have made the tracks being counted (Proulx and O'Doherty 2006). It is sometimes difficult to confirm that a series of tracks along a transect belongs to the same animal (de Vos 1951), as home ranges overlap (Buskirk and Ruggiero 1994), and winter dispersal movements are known to occur (Clark and Campbell 1976). On the basis of track characteristics, Proulx et al. (2005) deduced that tracks of two different animals could be as close as 100 m from each other along the same transect. To minimize spatial autocorrelation, only tracks >100 m apart within the same forest stand were recorded (Bowman and Robitaille 1997; Proulx et al. 2006).

In western North America, American Martens appear to be associated with late successional stands. Consequently, I hypothesized that American Marten tracks would not be distributed at random among habitat types, but that they would be more frequent in mature and old-growth stands. My hypothesis was declared before examining the track survey data. The proportion of inventory transects within each habitat type was used to determine the expected frequency of track intersects/habitat type (i.e., availability) if tracks were distributed randomly with respect to habitat types (Proulx et al. 2006). For each survey, I used a one-tailed Fisher Probability test (Siegel 1956) to compare the proportion of American Marten tracks in the habitat growth types, i.e., mature/old vs. immature/young. Data from the three inventories were pooled to increase sample size. Chi-square statistics with Yates correction (Zar 1999) were used to compare observed to expected frequencies of track intersects among habitat type. If the chi-square analysis suggested an overall significant difference between the distribution of observed and expected frequencies, comparisons of observed to expected frequencies for each habitat class were conducted using the G test for correlated proportions (Sokal and Rohlf 1981). Probability values ≤ 0.05 were considered statistically significant.

Results

Temperatures ranged from -21°C to 0°C and snow depths exceeded 45 cm during each inventory. Inventories were conducted ≤ 24 h after snowfalls or flurries, thus assuring that tracks were fresh.

In 1999, 41.1 km of transects were inventoried: 27.8 km (67.6%) in immature/young stands, and 13.3 km (32.4%) in mature/old stands. Eight tracks were recorded: 3 (37.5%) in young stands, and 5 (62.5%) in mature-old forests. The observed distribution of tracks was not significantly ($P = 0.31$) different from a random distribution of tracks among habitat types.

In 2002, 36.0 km of transects were inventoried: 16.6 km (46%) in immature/young stands, and 19.4 km (54%) in mature/old stands. Ten tracks were recorded: 1 (10%) in a young stand, and 9 (90%) in mature/old forests. The observed distribution of tracks was not significantly ($P = 0.07$) different from a random distribution of tracks among habitat types.

In 2005, 51.1 km of transects were inventoried: 27.1 km (53%) in immature/young stands, and 24 km (47%) in mature/old forests. Twenty-six tracks were recorded: 6 (23%) in young stands, and 20 (77%) in

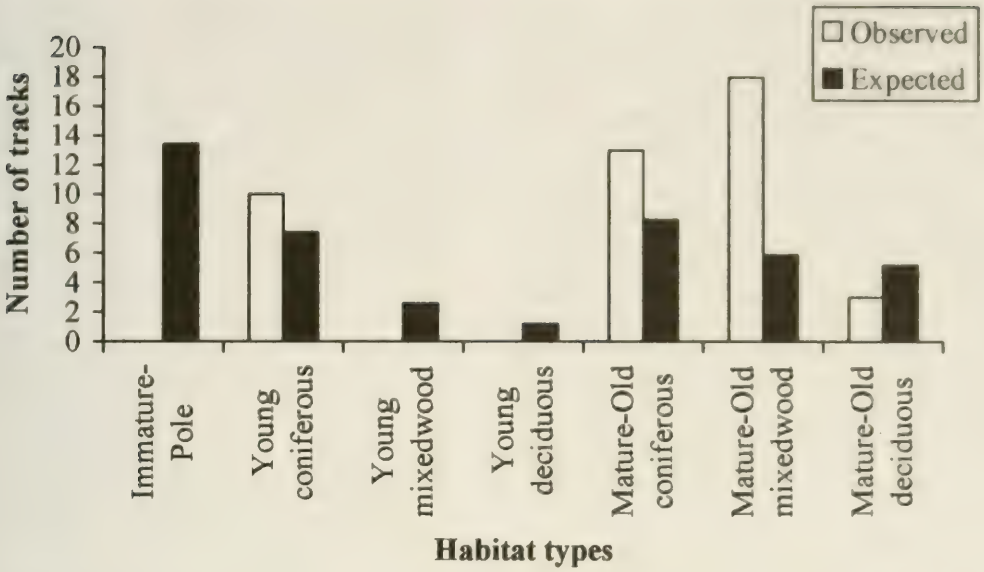

FIGURE 2. Observed and expected number of American Marten tracks per habitat type in Weyerhaeuser's Grande Prairie Forest Management Area.

nature-old forests. The observed distribution of tracks was significantly ($P = 0.002$) different from a random distribution of tracks among habitat types.

A total of 128.2 km of transects were inventoried from 1999 to 2005: 39.1 km (30.5%) in immature/pole stands, 32.5 km (16.9 % in coniferous, 5.8% in mixed coniferous-deciduous, and 2.7% in deciduous) in young stands, and 44.2 km (18.8% in coniferous, 13.5% in mixed coniferous-deciduous, and 11.9% in deciduous) in mature/old forests. Forty-four tracks were recorded: none in immature/pole stands, 10 tracks (22.7%) in young coniferous forests, and 34 tracks (77.3%) in mature/old stands (Figure 2). The observed distribution of American Marten tracks was significantly different from a random distribution of tracks among habitat types ($\chi^2 = 39$, df: 4, $P < 0.001$) (Figure 2). Tracks were significantly less frequent than expected in immature/pole stands (G = 17.2, df: 1, $P < 0.001$), and more frequent than expected in mature/old mixedwood stands (G = 6.42, df: 1, $P < 0.02$). The distribution of tracks suggested that American Martens used young forests, and mature/old coniferous and deciduous stands, according to their availability.

Discussion

In 1999 and 2002, because of small sample sizes, no significant difference was found in the distribution of American Marten tracks among habitat types. However, during both years, most tracks were in mature-old forests. Pooling data increased sample size and statistical power, and showed that American Marten tracks were definitely more frequent in late-successional stands. This finding is in agreement with previous studies conducted in western coniferous forests (Spencer et al. 1983; Wilbert 1992; Koehler et al. 1990; Therrien 2002; Proulx et al. 2006). American Martens prefer mature and old-growth forests over young and immature forests because this is where they maximize foraging efficiency and finding rest sites that can protect them from harsh environmental conditions (e.g., Powell et al. 2003).

Although young forests are believed to be suboptimal due to a reduction of necessary structure and diversity compared to mature and decadent forests (Thompson and Harestad 1994), in this study, nearly a quarter of American Marten tracks were located in young coniferous stands. As late/successional stands are decreasing in importance in Weyerhaeuser's FMA due to timber harvest, and oil and gas exploitation, American Martens may have to make greater use of young forests. However, previous studies showed that American Martens used young forests in winter where sufficient physical structure (Bowman and Robitaille 1997; Poole et al. 2004) and prey (Potvin et al. 2000) were present. More research on the characteristics of young forests used by American Martens is required to better understand their importance as winter habitat for this species in boreal ecosystems.

The fact that no tracks were recorded in immature and pole stands is in agreement with previous studies that have generally shown that American Martens make little or no use of early/successional stages

(Steventon and Major 1982; Thompson 1994; Thompson and Harestad 1994; Chapin et al. 1998; Heinemeyer 2002; Poole et al. 2004). Previous studies have also shown that American Martens appear intolerant of habitat fragmentation, and they would not tolerate more than 30-35% cutovers in their home range (Snyder and Bissonette 1987; Hargis and Bissonette 1997; Chapin et al. 1998; Potvin et al. 2000; Poole et al. 2004). In Weyerhaeuser's FMA, mature and old forests may be highly fragmented due to extensive clearcuts, and an important network of seismic lines and roads. Undoubtedly, these habitat modifications would have an impact on the distribution of American Martens, and cause shifts in home range boundaries (Poole et al. 2004). Forest development plans taking into consideration the winter habitat requirements of American Marten should therefore be developed locally according to the distribution of late/successional forests, cut blocks, and access networks (e.g., Proulx 2001*).

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Notes

Lady Crabs, *Ovalipes ocellatus*, in the Gulf of Maine

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The Lady Crab (*Ovalipes ocellatus*), mainly found south of Cape Cod and in the southern Gulf of St. Lawrence, is reported from an ocean beach on the north shore of Massachusetts Bay (42°28'60"N, 70°46'20"W) in the Gulf of Maine. All previously known Gulf of Maine populations north of Cape Cod Bay are estuarine and thought to be relicts of a continuous range during the Hypsithermal. The population reported here is likely a recent local habitat expansion.

Key Words: Lady Crab, *Ovalipes ocellatus*, Gulf of Maine, distribution.

The Lady Crab (*Ovalipes ocellatus*) is a common member of the sand beach fauna south of Cape Cod. Like many other members of the Virginian faunal province (between Cape Cod and Cape Hatteras), it has a disjunct population in the southern Gulf of St. Lawrence (Ganong 1890). The Lady Crab is of considerable ecological importance as a consumer of macrobenthic invertebrates, and is of biogeographic interest as a member of a large disjunct fauna. However, the distribution of the Lady Crab in the Gulf of Maine is unclear from the literature. Here we gather and discuss available reports of the Lady Crab in the Gulf of Maine and report an additional site that may represent a recent habitat expansion. This paper is intended as a basis for further work on Lady Crab distribution and for monitoring changes.

Lady Crabs have not generally been reported from the Gulf of Maine. Field guides (Gosner 1978; Meinkoth 1981; Miner 1950) and a review of tidal flats (Whitlatch 1982) give their northern limit as Cape Cod except for the disjunct Gulf of St. Lawrence population. Recent distributional studies of Gulf of Maine crabs show Lady Crabs on the south shore of Cape Cod and onto Georges Bank but no further north (Williams and Wigley 1977; Stehlik et al. 1991). This confirms the older work of Rathbun (1930). Williams (1984), and the update by Nizinski (2003), give the range briefly as Prince Edward Island to Georgia, but in this they may elide the northern New England gap. Pollock (1998) states the range as Virginian and Acadian, but again the range between the southern Gulf of St. Lawrence and Cape Cod is unspecified. The Lady Crab is not listed in Bay of Fundy, Maine, and New Hampshire checklists (Croker 1972; Brinkhurst et al. no date; Linkletter et al. 1977; Perkins and Larsen 1975) and distributional studies of the fauna of Maine sand beaches (Larsen and Doggett 1990) and mud flats (Larsen and Doggett 1991). Lady Crabs were not found in intensive local studies of western Cape Cod Bay (Davis and McGrath 1984) or Ipswich Bay (Dexter 1944).

Berrick (1986) reports Lady Crabs as common on Cape Cod Bay sand flats (which commonly reach 20°C in summer). The few other published records of Lady Crabs in the Gulf of Maine are from warm, estuarine habitats. Bousfield and Thomas (1975) identify a group of three warm water species which tend to co-occur (*Balanus improvisus, Urosalpinx cinera*, and *Ovalipes ocellatus*) but do not specify locations for the Lady Crab. Members of this group occurred in 1963 at: Cape Cod Bay, Duxbury and Cape Ann (Massachusetts); Cape Neddick and Boothbay Harbor (southern Maine); and the Bay of Fundy. Bousfield found Lady Crabs at Sesuit Harbor, East Dennis, Massachusetts, in 1964 (Judith Price, personal communication). Lady Crabs are reported in Salem Sound, Massachusetts, in 1997 by Chase et al. (2002). Although Dexter (1947) found no Lady Crabs in an intensive study of a tidal inlet at Annisquam (Gloucester, Massachusetts) in 1933-1940, he later (Dexter 1985) found them there during what he terms a period of warm water from 1952 to 1964.

We have found Lady Crab shells washed up on an ocean beach adjacent to the Essex and Ipswich river estuaries (Crane Beach, Ipswich, Massachusetts, 42°41'30"N, 70°46'20"W; 1995 and 1996). Fefer and Schettig (1980) mention, but do not specify, one or more southern Maine (south of Saco) locations from unpublished data by Doggett, Larsen, and Sykes. They were not found in the 1873 U.S. Fisheries Bureau investigation of Casco Bay which discovered several other warm water species (Verrill 1874). There are no records for the northern Maine cold water region (north of the Sheepscot River estuary) identified by Bousfield and Laubitz (1972) and confirmed by Larsen and

Doggett (1990). In the northern Gulf of Maine, there are several reports of Lady Crabs in the Bay of Fundy: Bousfield and Leim (1960) report Lady Crabs in the Minas Basin and Channel in 1922 (Bass River and Scotman Bay, noted also in Rathbun 1930) and again in 1959 (Bass River, Diligent River, and a cheliped on beach at Kingsport).

Bousfield and Thomas (1975) state that their Gulf of Maine records of Lady Crabs are from warm (circa 20°C summer temperatures – similar to their range south of Cape Cod) brackish water pockets or from estuaries with two-layer circulations where endemic warm-water populations could be maintained as described by Bousfield (1955) and Sponaugle et al. (2002). Bousfield and Thomas (1975) suggest these estuarine populations are relicts from the Hypsithermal warm era (9500-3000 years Before Present). The many Virginian invertebrates and marine algae now extending north to Cape Cod with additional disjunct populations in the southern Gulf of St. Lawrence had continuous ranges at that time. The short abstract by Dexter (1985) provides no details, but his 1952-1964 warm period may correspond to the 1951-1954 warming reported by Loder et al. (2001), with the crabs becoming locally extinct during the succeeding cold period (1959-1967). Dexter's observations suggest the possibility that the estuarine distribution is dynamic, populations becoming extinct and reestablished with changing conditions.

For the ten years we have been keeping records, Lady Crabs have been commonly found living on an ocean beach, called Preston Beach in Marblehead and Phillips Beach contiguously to the south in Swampscott, on the north shore of Massachusetts Bay (42°28'60"N, 70°46'20"W). There is no nearby estuarine habitat and the beach is exposed to heavy surf (unlike the Cape Cod Bay flats) [Leo et al. 2003]. Salem Sound is about six coastline miles to the north around the headlands of Marblehead/Marblehead Neck. This is the first reported exposed ocean beach location for Lady Crabs in the Gulf of Maine. Phillips Beach is in an area of wind-driven summer upwelling that keeps summer temperatures around 15-16°C (Geyer et al. 1992). Lady Crabs were commonly found swimming in shallow water and buried in sand just above low tide line. The habitat is thus very like that of the Lady Crab south of Cape Cod. Most of the living animals were found on the southern portion of the beach. This area is influenced by groundwater seepage on the high beach. Old faunal lists for Swampscott and vicinity yield no records of Lady Crabs: Grabau (1898) for Nahant, Revere, and Phillips Beach; Pearse (1913) for Nahant. This suggests our Massachusetts population may mark a local habitat expansion.

Discovery of other ocean beach populations and determination of the status of the estuarine populations would help clarify the distribution and habitat associations of Lady Crabs in the Gulf of Maine.

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Ring-billed Gull, *Larus delawerensis*, Food Piracy on Diving Ducks

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One of four Ring-billed Gulls observed 26 April 2002 at Dauphin Lake, Manitoba attacked a group of diving ducks and took abandoned food items.

Key Words: Ring-billed Gull, *Larus delawerensis*, Common Goldeneye, *Bucephala clangula*, kleptoparasitism, Manitoba.

Kleptoparasitism or piracy is the forceful taking of food by one species of bird from another (Terres 1980). According to Bent (1921) Ring-billed Gulls (*Larus delawerensis*) have been observed to hover over feeding ducks, notably Red-breasted Mergansers (*Mergus serrator*) darting at them as they re-surfaced apparently to steal their prey although success is not reported. Although Ring-billed Gulls do not usually pirate other gull species (Ryder 1993) they have been observed pirating food from European Starlings, *Sturnus vulgaris* (Burger and Gochfeld 1981). Clapp et al. (1983) state that a variety of species are pirated by the Ring-billed Gull. Jarvis and Southern (1976), in their study of the food habits of this gull in the Great Lakes region, made no mention of piracy or attempted piracy during the breeding season.

Crescent Cove at the south end of Dauphin Lake (51°10'N; 99°53'W) in west central Manitoba was windless and sunny but cold (-11°C) at mid morning on 26 April 2002. There, 15 m from shore, a stretch of water 70 m in length and 30 to 50 m in width had opened up parallel to a sandy beach. Small numbers of grebes and diving ducks, about 5 and 25 respectively, swam about on the calm surface, some diving for food. Ring-billed Gulls were also on the water, stood on the edge of the ice, or flew around in the area.

Upon my arrival on the nearby ridge above the beach 2 Red-necked (*Podiceps grisegena*), 3 Horned grebes (*Podiceps auritus*), 3 Redheads (*Aythya americana*), and 5 Canvasbacks (*Aythya valisneria*), and unhurriedly swam away leaving a half dozen Common Goldeneyes (*Bucephala clangula*) and 3 Greater Scaup (*Aythya marila*). With the ducks diving and returning to the surface, a Ring-billed Gull, only one of four gulls believed to actually be an attacker, typically took wing off the surface from among the waterfowl and flew low toward a duck up to 15 or 20 m away where it had just surfaced. Upon reaching the targeted bird, the gull flew up and hovered just above and behind its head as described by Bent (1921). The duck plunged out of sight and the gull, using its bill, snatched the food item surrendered. One attack was initiated from as close as 1.5 m.

Often a duck surfaced without prey and with several ducks diving it was remarkable how quickly and efficiently the gull identified a successful duck from the others and attacked it. Two prey items were identified: crayfish (Decapoda) and small fish which, when plucked from the water, were eaten on the spot after the gull alighted on the surface nearby or flew to a shelf of ice where the item was tossed down, re-grasped, then swallowed.

During the forty minute observation, attacks on the diving ducks were initiated 20 – 25 times. With one exception – a female scaup – all attacks targeted the goldeneyes. Other than one instance where four male goldeneyes directed a threat display involving the thrusting of their heads low over the water toward a nearby gull, little aggression was shown by the ducks. Avoidance of contact and hence injury from the gull attacks appeared to be paramount for the ducks. Frustration on the part of the ducks was not in evidence, but determination to capture more prey was.

In April at Dauphin Lake, carrion, notably discarded coarse fish from ice fishing activities, would seem to be an important source of food for early arriving carnivorous or omnivorous birds from the south such as gulls, Bald Eagles (*Haliaeetus leucocephalus*), American Crows (*Corvus brachyrhyncos*) and some species of hawks, in addition to resident populations of the Common Raven (*Corvus corax*). A possible shortage of fish and/or other sources of food in the Crescent Cove area of the lake and, perhaps, on the lake ice generally due to competition, may have been a factor in the gulls' attacks on the goldeneyes. Observations of the lake from shore at Crescent Cove with the use of a 20 power spotting scope that day revealed only one such food item, the carcass of a Canada Goose (*Branta canadensis*) lying on the ice 250 m out. In immediate succession at this source of carrion, included: a Northern Harrier (*Circus cyaneus*) with two crows nearby; an adult Bald Eagle that causing the harrier to fly off and three immature Bald Eagles that displaced the adult eagle at the carcass; all to the exclusion of any gulls, suggesting intensive competition for food. This competition may have resulted in the unusual method of securing food observed in at least one Ring-billed Gull.

Acknowledgments

I thank Ken Kingdon of Parks Canada, Riding Mountain National Park, for literature concerning the

Ring-billed Gull – Red-breasted Merganser record. Appreciation is also extended to A. J. Erskine and other reviewers whose constructive comments were well received.

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Probable Black Bear, *Ursus americana,* Retrieval of an Elk, *Cervus elaphus,* Carcass from a Small Lake in Riding Mountain National Park, Manitoba

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Walley, William J. 2006. Probable Black Bear, *Ursus americana,* retrieval of an Elk, *Cervus elaphus*, carcass from a small lake in Riding Mountain National Park, Manitoba. Canadian Field-Naturalist 120(1): 110-112.

Strong circumstantial evidence indicated that a sow Black Bear (*Ursus americana*) retrieved an Elk (*Cervus elaphus*) carcass from near the middle of a small lake to feed herself and three cubs.

Key Words: Black Bear, *Ursus americana,* Elk, *Cervus elaphus,* carcass, small lake, Riding Mountain National Park.

Accounts of observations of Black Bears (*Ursus americana*) retrieving carcasses from bodies of water are difficult to locate, even those based on circumstantial evidence. Studies of food habits of Black Bears by Hatler (1972) and Machutchon (1989) cite no such instances. Herein is provided a description of a series of observations that lead to the conclusion that an Elk (*Cervus elaphus*) carcass was brought to shore from mid-lake by a female Black Bear.

The observation reported was made at Grayling Lake (50°47"N, 100°W) in Riding Mountain National Park, Manitoba. This is a kettle lake (Lang 1974) and as such is deep (9 m) for its small surface of approximately 25 hectares. It is situated well below surrounding rolling hills in mixed forest about 9 km north of Clear Lake. With the exception of an 80-m gap to the NW and the lake outlet through sedge and grass meadows to the north, tall spruce (*Picea*) trees encircle and shelter Grayling Lake.

At 0815 on 2 August 2004 under full sunshine a large object was seen floating just west of the middle of the lake by the author and two companions from north-south orientated Highway 10 that passes just to the west of the lake (Figure 1).

Identification of the brown-gray object was not made even with 8 × 40 binoculars. At 12:15 that day the lake was re-visited. Though air movement was almost negligible, the object had been moved close to the east shore, where two Coyotes (*Canis latrans*) fed on it. Some 50 m to the north, a Black Bear was unhurriedly walking north away from the carcass and the Coyotes. It then disappeared into heavy coniferous forest. Shortly after, the Coyotes moved off and a bear appeared at a small partial clearing above the shore and the carcass. In subsequent days the bear, from this point, repeatedly chased off Coyotes but tolerated the intensive food collecting activity of a pair of Common Ravens (*Corvus corax*). On 3 August a sow led her three cubs to the carcass, where they fed.

In the next few days the remains of the carcass were identified as cow Elk (*Cervus elaphus*) by Ken Kingdon

Table 1. Wind direction and speed in km/hr in Riding Mountain National Park 2 August 2004*

Time	At Wasagaming	At old Kippen's mill site	
08:00	NW 6	SW	3.6
09:00	NW 4	NW	6.3
10:00	NW 9	NW	8.1
11:00	NW 7	WNW	7.8
12:00	NW 11	NW	8.6

*Recorded by Environment Canada (personal communication, K. Kingdon, 2005)

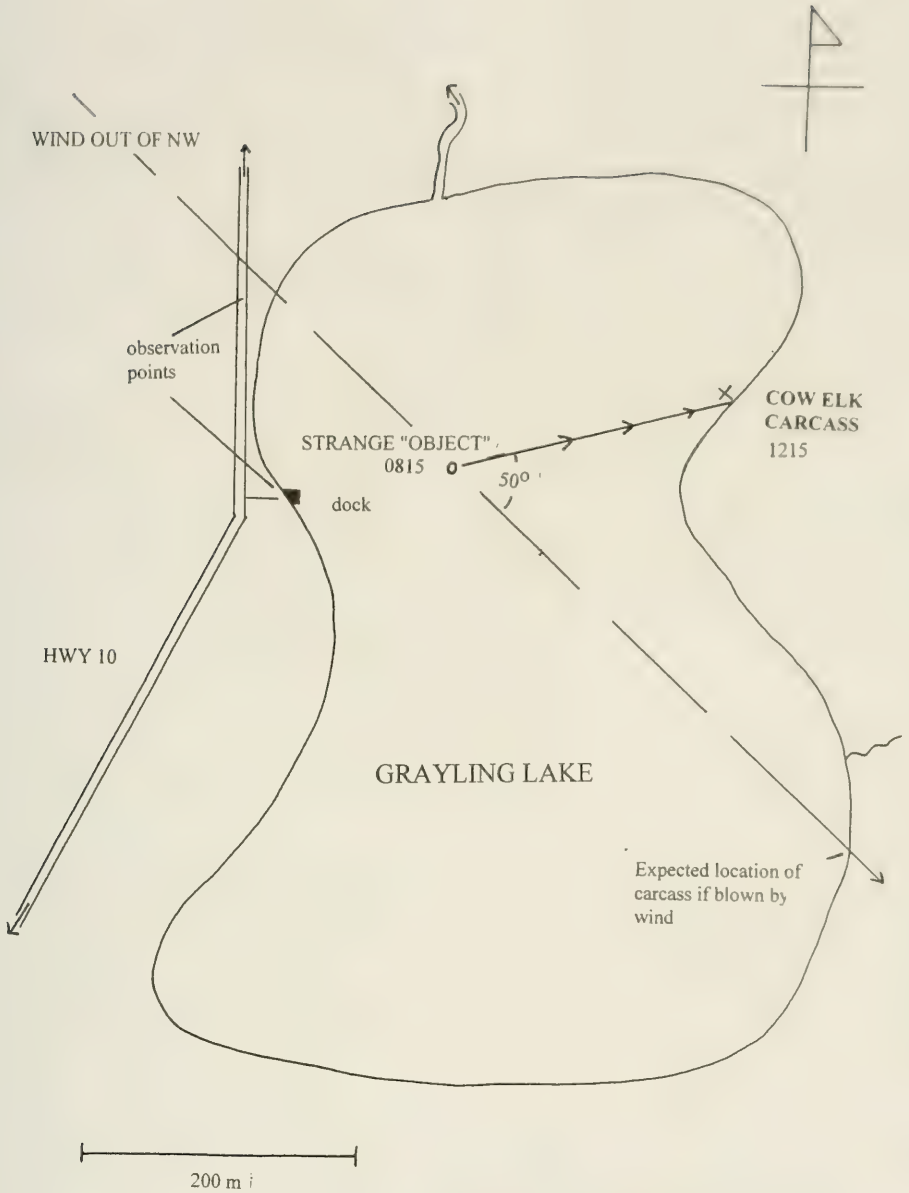

FIGURE 1. Elk carcass locations relative to wind direction, Grayling Lake, 2 August 2004.

of Parks Canada (personal communication) and independently by the author.

It was hypothesized that the bear had retrieved the carcass from the lake and had to swim out at least 200 m to get it. Veteran Parks Canada Warden Pat Rousseau (personal communication), an expert on Black Bears, concurred. In his experience he had not actually seen bears drag Elk carcasses ashore but, from an aircraft, had seen a Black Bear swimming halfway out toward an Elk carcass 40 m from the shore of a lake. On another occasion he had seen Black Bear and Gray Wolf (*Canis lupus*) tracks associated with an Elk carcass on the shore of a remote lake in the park. In the mid-1990s a party of hikers reported an animal with a black head behind a carcass in deep water of Bead Lake Four less than 3 km NW of Grayling Lake. The only scavenger other than a bear that it might have been mistaken for would be the much rarer Wolverine (*Gulo gulo*) (Pat Rousseau, personal communication).

Environment Canada wind data in the critical time period that day (08:00–12:00) showed only very light breezes primarily from the NW which almost certainly eliminated the wind as being a factor in the carcass being blown to the east shore (Table 1) (Figure 1). On

a similarly calm day, 13 August, blocks of wood were placed in the middle of the lake to see if water currents would carry them to the east shore.

No definitive proof was obtained that the bear swam out and hauled the carcass a minimum of 200 m to shore. However, the negative results of the water currents experiment coupled with the data on wind direction and speed that day provided a strong suggestion that this is what happened. Still, it is possible that another species of scavenger (e.g., Wolverine) brought the carcass to shore, and then abandoned it. Further, although none was seen before 08:15 or after 12:15 there is a possibility that, while the carcass was unobserved by the author between these times that day, one or more people kayaking or canoeing on the lake took the carcass to the east shore. Interviews with such recreationists at the lake on subsequent days revealed no knowledge of the carcass being moved. Hence, both of these scenarios seem very unlikely.

In retrospect, the bloated condition of the carcass near the middle of Grayling Lake on 2 August doubtless produced a powerful olfactory stimulus for the bear and her cubs.

Acknowledgments

I thank Parks Canada Warden Patrick Rousseau for his accounts of Black Bears and Elk and Warden Service Communications Officer of Riding Mountain National Park, Ken Kingdon, for providing information on wind speed and direction. Appreciation is also extended to the reviewers of the manuscript who made constructive comments and gave suggestions.

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Book Reviews

ZOOLOGY

The Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi

By Terry Stevenson and John Fanshawe. 2006. Princeton University Press: 41 William Street, Princeton, New Jersey, 08540 USA. 640 pages U.S. $35.00 Paper.

Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, and Burundi is one of a number of bird guide books on this region. Indeed, this publication is a paperback version of the award-winning 2001 hardback edition. It has not been updated.

The first of these books I bought was *Birds of East Africa* by Williams and Arlott, published in 1963. At the time I was very pleased at the style and quality of this work. Some 665 species were illustrated. In 1999 this was superseded by *Birds of Kenya and Northern Tanzania* by Zimmerman, Turner and Pearson. This book was a giant leap forward with 1084 species illustrated (even though this only covered 40% of the area of East Africa.) The illustrations increased by 419 species despite the smaller area covered. Also the quality of the artwork and printing was far better and was a closer match to European and North American guides. Now we have the new *Birds of East Africa* with Norm Arlott again providing much of the artwork. This volume illustrates 1388 species and is another, although smaller leap forward.

Birds of East Africa covers the resident, migrant, and vagrant bird species of Kenya, Tanzania, Uganda and the two smaller countries of Rwanda and Burundi (the area of these two together is less than 3% of the region, but adds a surprising number of species to the list). The text is high quality and faces the colour plate page (a more convenient format). The species accounts describe identification, status, range, habits, and voice. The colour distribution maps are small, but clear.

The question now arises, which is the better book for the visitor going on typical trips to the major parks in Kenya and northern Tanzania? *Birds of Kenya and Northern Tanzania* is slightly smaller (around 5%) and covers less territory. While this loses about 20% of the species, most of these are specialist species confined to Uganda, Rwanda and Burundi (about 225 species that are wholly or primarily confined to those countries). The remainder are species predominantly from southern Tanzania.

To my eye the artwork in *The Birds of East Africa* is noticeably better both for the colourful species and the LBJ's ("Little Brown Jobs": warblers and Cisticolas), but this not a huge difference. I checked several species from my slide collection and found *Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi* was generally more accurate. The user will find it very difficult to separate Long-billed from Tawny pipit using *Birds of Kenya and Northern Tanzania*, but will find only a small improvement with *Birds of East Africa* as these birds are difficult to separate anyway.

There is not much to choose between the texts (although it is more extensive in *Birds of Kenya and Northern Tanzania*) and the coverage of endemics is very similar. It is easier to have the text, illustration and map side by side (*Birds of East Africa*). The biggest difference lies in the range maps. The *Birds of East Africa* shows only a single range designation, covering winter, summer and migratory ranges. In comparison, *Birds of Kenya and Northern Tanzania* shows summer and winter ranges separately. Just as important, *Birds of Kenya and Northern Tanzania* more clearly defines where the birds are located. For example waterside birds like bitterns and herons are show in localities where water occurs. Similarly plains species are shown in the plains. The *Birds of East Africa* maps blanket the entire area that water birds can occur giving the impression they can be anywhere, even in dry savannah.

Birds of Kenya and Northern Tanzania includes a map of region inside its front cover that shows the key locations mentioned in the text. Although *The Birds of East Africa* has maps that show features (like forest cover), they do not depict the location of national parks, cities, etc. Neither book gives alternative names, which is a bit irritating when making comparisons with park checklists, older books, trip reports etc. (e.g. *Schoenicola brevirostris* is called the Fan-tailed Grassbird or Broad-tailed Warbler and not to be confused with *Cisticola juncidis* called the Fan- tailed Warbler but now known as the Zitting Cisticola.)

If you are planning a trip that includes Kenya, Tanzania, Uganda, Rwanda or Burundi, *The Birds of East Africa* is the more valuable book to take with you. When I go to Kenya and Tanzania later this year, the extra information given by the range maps would prove beneficial (These more detailed range maps will be particularly useful for the first time visitor.), but I am taking *Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi* because of ease of use and higher accuracy of the illustrations.

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The Birding Sites of Nova Scotia

By B. Maybank. 2005. Nimbus Publishing Ltd., 3731 Mackintosh St., Box 9166, Halifax, Nova Scotia B3K 5M8 Canada. 654 pages, $35.

There is a path that runs from a popular beach in southern Nova Scotia. If you know exactly where, you can leave this path and cross several hundred metres to the start of a more secret path. This second path runs through a spruce grove along a cliff. If you know exactly which spruce to slip behind, you will find a hidden rope that will allow you to drop several metres down a cliff face. You will be in a very secluded cove with a golden beach and blue water, sheltered from any cold wind. This secret spot must be the only place in Nova Scotia that Blake Maybank has not visited! His new book is an incredibly detailed set of directions to (almost) every tiny nook of this beautiful province.

The main purpose of this book is to give sufficient directions for the visitor or native Nova Scotian to find the numerous coves and special places that dot the province. This is not as easy as it sounds as some of the roads and tracks are obscure and hard to distinguish. For example, I know native-born people who did not know of the track to Cherry Hill Beach, even though they had driven past it many times. This is because it is tucked between houses and looks like a driveway. Very sensibly Maybank has given the GPS coordinates of this location and others where someone might have trouble.

At each locality the author describes the habitat and comments on the birds typically to be found there. He also includes cultural highlights such as churches, lighthouses, museums and other tourist attractions. Although the title suggests this book is only about birds, Maybank includes similar information on mammals, butterflies, reptiles and amphibians. Where noticeable he comments on the wildflowers but this is not a focus. Each section has icons representing the types of birds, plants or mammals found and other key features like washrooms to be found on the site.

Giving directions can, of necessity, be dry reading even (or especially?) when they are given in great detail. The writer's style is much more upbeat and entertaining in the other sections. I was amused to read (Meat Cove) is "beyond the radar ... its delights are shared by a privileged minority" (Meat Cove, despite its name, is indeed a beautiful place of seabirds, orchids and gorgeous scenery; naturalists should certainly go there). Maybank does not give a detailed account of all the birds likely to be seen at a given locality. He uses generic terms such as gulls, shorebirds and warblers. However he has set up a website where you can access bird lists and information on the key localities. I assume he plans to keep this site current, so it is much more useful then putting a list in the book (which would soon be dated).

There are a few items that I think need changing. Page 243B has lost part of its text, an obvious printing problem. The author states "There are no deer ticks ... hence no Lyme disease." It is not this simple. Dog ticks (*Dermacentor variabilis*) also carry the Lyme disease bacteria, *Borrelia burgdorferi* (technically they are "infected", but maybe not "infective"). Whether or not the *D. variabilis* tick transmits Lyme disease is not yet resolved, suggesting caution. I was dismayed to see he did not mention Grassy Island (and hence Roseate Terns) in his account of Pearl Island (perhaps the last pair has been extirpated). The book has no index, meaning you will need a map to get you oriented. (Find the county you want and use the index to get you to the correct chapter.)

Any traveler who has gone to the expense of traveling to Nova Scotia needs this book; it will be invaluable. They will get to more places and see things they would have missed. Nova Scotians will also benefit. I doubt if anyone has traveled so widely and could provide such a precise record as Maybank. I will be using this book for my upcoming trip to Ile Madame in Cape Breton. As my last trip was in winter, I look forward to more informed and interesting birding this time.

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The Complete Fauna of Iran

By Eskandar Firouz. 2005. I. B. Tauris. London, New York. xiv + 322 pages. US $90.

This book covers the vertebrate fauna of Iran, mammals, birds, reptiles, amphibians and freshwater fishes. It is a revised, English language version of a 2000 publication by the same author in Farsi (reviewed by Coad and Keivany 2002). Those fluent in Farsi might prefer that version at the bargain price of $5.63!

Iran is a country that often appears in the political news for its great economic and strategic geographical importance. This is mirrored in its vertebrate fauna, which includes such famous economic species as the caviar-bearing sturgeons and many diverse species of interest to naturalists close to its location at the intersection of the Palaearctic, Ethiopian and Oriental realms.

The Introductory sections of the book are particularly valuable for readers not familiar with this part of the world, and encompass 48 pages. A transliteration system is explained for the Farsi common names of organisms (a local language name list is always useful as scientific names may be more of a barrier than a

help outside academia), the distribution of Iranian provinces is mapped, major freshwater drainage basins outlined, and topography summarized in colour. A summary of zoological work in Iran follows with accounts of the transition between hunting and falconry to conservation and protection. Iran now has an impressive list of 16 National Parks, 13 National Nature Monuments, 33 Wildlife Refuges and 92 Protected Areas. Summaries of physical geography, climate, vegetation, zoogeography, threatened species and some fossils follow, illustrated by colour habitat photographs. Appendix I lists all the parks, their area, year established and a grid reference for a map in the Introductory section. Appendix II describes the Pardisan project (from the Old Persian for paradise), a 270-ha park in Tehran intended to replicate Iranian environments as an innovative educational project and centre for research in all fields related to the natural world. Conceived by Firouz, Pardisan was meant to be an academy of sciences, a zoo, herbarium, aquarium and museum. Hopefully it will come to fruition. The Bibliography encompasses 7 pages and is a general introduction to the literature on Iran. This literature is surprisingly diverse and could not be covered in this book – that on freshwater fishes, for example, numbers over 2900 items (see www.briancoad.com). The book ends with indices to Latin and English names of vertebrates and a general index.

The mammals occupy 60 pages, birds 88, reptiles 54, amphibians 10 and freshwater fishes 34. The number of mammal species referred to is 168, birds 514, reptiles 199, amphibians 20, and freshwater fishes 173, for a total of 1074. Because of space limitation, not all species are described. Introductory sections give an overview of work on each group and an update from the 2000 edition in Farsi; e.g., six species of mammals have been added to the fauna. Iranian scientists became very active in the 1990s and subsequently, as evidenced by their publications in such journals as *Zoology in the Middle East*. Comments are made on conservation and the destruction of habitats that threaten so many species, here as in the rest of the world.

As an example, the first family dealt with, the hedgehogs, number four species which are listed by English name, Farsi name in English script, Latin name and a numbered listing of the provinces in which they occur. This requires the reader to find the map of provinces at the front of the book, and these maps are very small (15 by 10 mm), and would require a knowledge of Iranian geography to interpret easily. Any illustrated species is indicated by a diamond next to the English name. A general review of hedgehog biology precedes this list. No mention is made of the absence of hedges in Iran (where hedgehogs are found in burrows, bushes and rock crevices), and the disconcerting habit shown by some species of hissing loudly when disturbed is also omitted, an attribute not noted in the more sedate English hedgehogs.

Mammals of note, and evidence of the land bridge that Iran forms between Europe, Asia and Africa, include lions and tigers (both now, sadly, extinct), Egyptian fruit bats, wolves, red foxes and jackals, cheetahs, leopards and lynx, hyenas and badgers, deer and gazelles, and jerboas and hares. The plan to re-introduce lions from India to southern Iran is noted but not whether this actually took place. Rumours in the 1970s had them introduced, but quickly wiped out by local villagers who were not ardent conservationists when faced with a potential predator on their sheep and goats, not to mention sleepy goatherds and shepherds. The illustrations are a mix of photographs and colour drawings.

The birds are illustrated mainly from colour drawings provided by Birdlife International and are a good summary of that fauna. Necessarily, this section in particular must be quite abbreviated in its text, given the bird diversity, but books devoted to birds are widely available for the fauna of the Middle East. Status symbols are given for each species rather than provincial distributions as with mammals; e.g., R = common resident, r = scarce resident, again a system that requires reference back to the page listing 16 possibilities. These could certainly have been included with each species' name in an abbreviate form.

The reptiles are well-illustrated with colour photographs. The fauna is varied and interesting but not evident without effort in field situations. I seldom saw snakes and lizards while living in Iran although small geckos could be found on house walls (and had a ferocious bite). One of the largest lizards readily encountered is the Bengal Monitor which reaches 2.75 m. Chasing one of these rapid lizards across the desert could be quite tiring if they did not try to hide behind a bush much too small to conceal their length. Marsh crocodiles live in the southeast of Iran, much decimated by drought in the late 1990s. They are here reported as not attacking people, a fact I wish I had known in the 1970s when I might have sampled their home streams for fish less nervously. Five species of marine turtles are known from the Persian Gulf, all badly in need of protection.

The amphibian fauna is small in species although toads and frogs are common in and near water. Tree frogs are found on banks of streams, trees being rare in much of desert Iran.

Extensive critical comment on the freshwater fishes would be inappropriate given the input by this reviewer. Only freshwater fishes are dealt with, although this includes Caspian Sea fishes where salinities are about one-third of sea water. The diverse fauna of the Persian Gulf and Sea of Oman are not covered—a recent summary work is Assadi and Dehqani Posterudi (1997). One loss of information is that space does not always allow for a full explication of evocative Farsi names. The enormous sturgeon, *Huso huso*, reaching 1.5 tonnes and 6 m in length, is known as fil mahi which

translates appropriately as elephant fish while the pike, *Esox lucius* is ordak mahi, duck fish from its duck-like snout.

The author is eminently qualified to write on this topic having been the Director of the Department of the Environment and vice-president of IUCN. He is regarded as the father of Iran's environmental movement. The Farsi version of this book won the Iranian Publisher's Association top award.

This book is highly recommended as a well-written overview of a fascinating fauna.

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Coad, Brian W., and **Yazdan Keivany.** 2002. Review of "A Guide to the Fauna of Iran." E. Firouz. 2000. Iran University Press (University Publication Centre), Tehran. ISBN: 964-01-0956-8. vi + 491 pages. 45,000 Rls ($5.63) (hardbound)". Copeia 2002(4): 1164-1166.

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Fishes of the World

By Joseph S. Nelson. 2006. John Wiley & Sons, Hoboken, New Jersey. Fourth Edition. xvii + 601 pages. U.S. $125.

This book covers all the 515 families of fishes in the world in 62 orders and 5 extant classes. Fossil families are more briefly treated. Each class, subclass, order, suborder, family and subfamily receives a brief description. In this way the reader is treated to a tour of the world's fishes through their higher classification and relationships. This being the fourth edition, 30 years after the first, proves the need, and success, of such a work. Scientists and students look to this work for an overview of fish classification and, with an estimated 28 400 species at the end of 2006 compared to about 26 730 tetrapods (mammals, birds, reptiles and amphibians), the fishes need this structure. At the individual species level, constantly changing as new ones are described or old ones revised, the online "Catalog of Fishes" from the California Academy of Sciences is the update source (www.calacademy.org/research/ichthyology/catalog/index.htm).

A website, http://members.shaw.ca/fishesoftheworld/index.htm contains errata, a list of new families post-1958, student exercises and links to relevant websites. Changes in the numbers of taxa between the four editions of the book are listed in the table below.

Variation in the number of families is mostly due to lumping and splitting as Nelson points out at the website mentioned above. Discovery of new families is a rarity in fishes. However, the estimated number of known fish species for the end of 2006 cited above is almost 10 000 more than in 1976, showing that this field of endeavour has been most active.

The text has continued to be expanded over the earliest editions, with families once without a description now provided with one. Much necessarily remains the same from the last edition as relationships, anatomy and species content remain unchanged in certain families. Not all genera are listed within each family, although a couple listing would be a great convenience, and not all families have a line drawing (about 74% do). Some families have undergone significant changes, with new information on species numbers, ecology and fossil members added, including the new coelacanth found in a fish market. Several groups (e.g., Characiformes, Osphronemidae) have been rearranged based on new systematic studies, and Nelson makes a concerted effort to follow a cladistic framework. However, as Nelson notes in his preface, it is naïve to accept the latest proposals as being the best. Nelson has used his own considerable judgment in determining which groups are sufficiently systematically stable to include. This has also resulted in some families (e.g. Cichlidae) losing some structure, as new studies have shown past taxonomic groupings to be non-monophyletic.

The literature on fish classification is extensive, sometimes arcane in its arguments, and scattered in journals worldwide. Having an author mull over this literature and provide an interpretation and digest for consideration is a great service to students and to those professionals who need to dip into these waters at intervals.

In this new edition, Nelson has included many more references, providing the most recent literature. The Bibliography is comprehensive and covers 54 pages. Some authors may be disappointed that not all their papers are cited, but Nelson has generally included good summary papers that will provide, within their own references, many titles of more specific articles.

The Index at 63 pages is also most useful in locating particular taxa but certain genera will not be found (as noted above) and the reader will have to resort to *Catalog of Fishes*. Additionally, the previous edition used the names of orders as the running header throughout the text. The use of the more inclusive class level as the running header in the new edition is less helpful in flipping through to find the desired pages.

Year	Species	Freshwater	Marine and Diadromous*	Families	Orders	Classes
1976	18,818	6851	11,967	450	46	4
1984	21,450	8411	13,312	445	50	4
1994	24,618	9966	14,652	482	57	5
2005	27,977	11,952	16,025	515	62	5

The single disappointment of the new edition is the loss of the chart of categories and relationships of fishes from the inside front cover. It is now buried on (unnumbered) pages xvi-xvii, between the Acknowledgments and the Introduction, making it much harder to find. Owners of the book may want to place a permanent bookmark in the chart for quick reference. The new chart, while showing better resolution of groups in this edition, has also lost all the names between Class and Order. While some of these names were for non-cladistic grades, their presence on the previous edition's chart was of great benefit, particularly for students, to determine exactly what is a "teleost" or "actinopterygian", or any of the other names that are commonly used by ichthyologists.

At the end of the list of errata on the website given above, and on page 9 of the new edition, Nelson draws attention to the need for ichthyologists, and the work that still remains for future generations. He urges us to support the replacement of retiring ichthyologists to continue the work. The Introduction of *Fishes of the World* provides a sampling of all the rich areas of ichthyology to be studied and highlights the importance of fishes to all of us. Perhaps if the Introduction were required reading for everyone, Nelson's enthusiasm for fishes would be passed on to all, and the worth of ichthyological research would be clearly visible to governments and society. This book continues to be a seminal work, finding an essential place in libraries and on the bookshelves of anyone interested in fishes.

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Insects: Their Natural History and Diversity: With a photographic guide to insects of eastern North America

By Stephen A. Marshall. 2006. Firefly Books Ltd., 66 Leek Crescent Richmond Hill, Ontario L4B 1H1 Canada. 720 pages. Can $95. Hardcover.

It has always been said that you can't judge a book by its cover, but after reading *Insects: Their Natural History and Diversity* I've learned that this well-worn axiom isn't always true. When this book first crossed my desk, to say that I was instantly enamoured would be an understatement. It was so beautiful, the cover adorned with a stunning jewel-toned dogbane beetle (*Chrysochus auratus*). I almost didn't want to crack the binding. However my curiosity finally got the better of me and I'm glad it did because once I started reading I couldn't put the book down.

Visually stunning, with over 4000 color photographs of insects in their natural habitats, *Insects: Their Natural History and Diversity* has the look and feel of a glossy coffee table book while still being full of accurate, well researched information.

As its title implies *Insects: Their Natural History and Diversity* focuses on the diversity and natural history of common families of northeastern North American insects. The book opens with a brief synopsis of basic insect anatomy and morphology. This is followed by chapters covering the diversity of all insect orders, including all the major families, along with two chapters on non-insect arthropods and methods for observing, collecting and photographing insects. The book's last 50 pages are dedicated to illustrated keys to order and family as well as a key to the most commonly encountered insect larvae. These keys are designed to facilitate ease of use and therefore emphasize morphological characters visible to the naked eye or easily seen with a hand lens. Also peppered throughout the book are helpful suggestions on where to look for and find various insect orders/families. For example "Depending on your inclination and the weather, a good place to start looking for assassin bugs would be in your kitchen light fixture. Unless you are much more fastidious than most, the odds are that among the crispy critters accumulated there you will find a large black assassin bug called the Masked Bed Bug Hunter (*Reduvius personatus*)."

Considering that *Insects: Their Natural History and Diversity* is priced so as not to be cost prohibitive and is clearly written in plain language makes it highly accessible to a broad audience including naturalists, amateur entomologists as well as seasoned professionals. The author has also included a dollop of humour and wit throughout the text. For example this passage describing the appearance of springtails: "Some are covered with scales, like those of a butterfly, many are brilliantly colored and all are morphologically bizarre, starting from the long, forked tail used to make Herculean leaps, and ending with the deeply pocketed mouth that makes springtails look like they have lost their dentures and then sucked on a bunch of lemons."

This book would make a great textbook for a natural history or general entomology course. Especially when you consider that the impetus for this book centers on materials originally gathered in support of the author's third-year course "The Natural History of Insects" at the University of Guelph. With its depth of scope and true-to-life color photographs *Insects: Their Natural History and Diversity* would be indispensable in the field; however, due to its size it would be a bit unruly to have to lug around.

I thoroughly enjoyed this book and would recommend it whole heartedly to anyone who has an interest in entomology, natural history or a simple curiosity about the six-legged world that surrounds us.

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Secret Weapons – Defenses of Insects, Spiders, Scorpions, and Other Many-Legged Creatures

By Thomas Eisner, Maria Eisner, Melody Siegler. Belknap Press of Harvard University Press, Cambridge. 2005. 372 pages.

This book is dominantly about chemical defences of terrestrial arthropods, though other types of defences (camouflage, catapulting, sticky traps) are also mentioned. Chapters are short, and typically feature the defences of one organism, or at most a small group of related organisms. One or more colour photos, in themselves almost worth the cost of the book, enhance both the aesthetics of the book and the ability to drive home each chapter's message. Chemical formulae are illustrated in those chapters focusing on chemical defences.

As the subtitle alludes, an array of terrestrial arthropods is dealt with, but by far, the majority of this book is about insect defences. However, scorpions, centipedes and other non-insects together account for about 15% of the book's material. Examples include the well-known spray of the Bombardier Beetles, the less well-known vomit attacks of noctuid moth caterpillars and immobilizing wax of oleander aphids.

This book will appeal to a wide array of readers, the caveat being that those with no (or little) training in chemistry (like me) will miss out on some of the nuances of the chemicals themselves; this did not give rise to any problems at all for my enjoyment of this book. The other caveat being that those not liking those long, tongue-tripping scientific names of organisms will have to gloss over them periodically as they read; even where common names exist for the organism of the chapter's focus, the scientific name is typically used throughout the text. Grade-school children will be able to use this book though clearly not as completely as older folk; entomology instructors could easily incorporate this material into lectures. Truly, this book can meet the needs of many.

There is an abundant amount of fascinating material that simply makes this well-written book a joy to read; I have been equally satisfied after having read Waldbauer's books, including *What Good are Bugs?* (also from Harvard Press). Unlike the latter book, the chapter bibliographies of *Secret Weapons* are replete with papers of the book's authors, particularly the Eisners. Their work in chemical ecology, translated by them from their papers to this book, is a grand example of making science more consumable by the non-specialist.

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Rodents and Lagomorphs of British Columbia

By David W. Nagorsen. 2005. Royal British Columbia Museum, Victoria, British Columbia.

I read this book both with a general interest in mammals overall, and, as a raptor biologist, a desire to more completely understand the creatures which are the prey of my birds. I was not disappointed on either account. From a simply presentational point of view, the artwork sticks out as being very aesthetically pleasing. Each species is illustrated with a pencil drawing of the complete animal – not in a standard three-quarter pose or profile, but in varying postures that show snapshots of each animal's character. Additionally, the skull of each species is presented in lateral, dorsal and palatal views – perhaps this is not useful to the general reader, but I certainly benefited from them; the illustrators (Michael Hames, Donald Gunn and Bill Adams) must be commended.

The book has three keys – one each for whole animals, skulls and chipmunk genital bones. Anyone who has used an unillustrated key understands the frustration of trying to interpret the author's meaning (what is meant by "relatively large?"). A fully illustrated key has diagrams for each couplet – the keys in this book are not fully illustrated, but there are plenty of diagrams that make the process of keying out an organism rather straightforward.

An introductory chapter describes the biogeography of British Columbia, along with conservation strategies, winter survival and several other topics which link these species together. Maps and good photographs are featured here.

The species accounts dominate this book. Each runs about six pages and describes physical aspects of the species, its natural history, geography, and conservation status. An occurrence map accompanies each account; I believe British Columbia residents and non-residents alike would have benefited from place names being included on the maps – especially those which are only mentioned once or twice in the whole book. Similarly, even the introductory maps do not include all the major sites mentioned in the book.

There are a small number of mistakes, some editorial (e.g. "supraorbital bone" is used instead of "supraorbital process"), some factual (e.g. "[The muskrat has] rooted cheek teeth."). In the introduction to the lagomorphs, I think it would have been appropriate to differentiate rabbits from hares.

I take particular exception to the oft-used expression that some introduced animal (in this book, the Eastern Cottontail) "seems to be filling an ecological niche." This is at best an empty comment (what introduced animal would not have a different ecology than the natives) and at worst could be interpreted as an excuse to tolerate and perhaps enhance introductions.

Those few shortcomings aside, this is a very good book which serves its purpose admirably. I will refer to it frequently.

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Tanagers, Cardinals, and Finches of the United States and Canada

By D. Beadle and J. Rising. 2006. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA 196 pages, U.S.$29.95 Paper.

The authors use 200 selected photographs to complement text covering the biology, identification, molts, song and distribution of the tanagers, cardinals, and finches found north of Mexico. In all, forty-six species are covered. Of these, one is an introduced species and 31 are native residents of some part of North America. The remaining 14 are vagrants with five as Alaska specials and seven creeping north over the southern border.

I have just spent a couple of hours resolving an identification issue using about 20 photographs off the Internet (out of the 200 I found there) of a single species. Most of those photos were of limited use. Normally I find such photographs less useful than artwork because they are so influenced by light, angle and the condition of the specimen. However, my jaundiced eye is very impressed with the photographs in this book. I do believe that I would be able to separate female House and Purple finches using the photographs and text given in this book. Indeed I used this book to confirm that I had correctly identified a Hoary Redpoll I saw recently in the Arctic. The typical resident species are represented by several photographs taken at different angles thus giving the reader a better understanding of the bird.

The 31 residents each have a range map giving summer, winter, and permanent ranges. These are about 5.5 cm square and very readable and useful. There is a written description of range too, which adds more detail. I had no difficulty deciding I was at the northern edge of my Hoary Redpoll's range. The text is clear and provides great detail without wasted words.

The vagrants are similarly treated, but do not have a range map. Under distribution their normal range (outside of North America) is described, followed by a summary of their occurrence in North America, with additional details, such as precise locations and dates, where warranted.

This is a very useful supplementary guide (to the classical all-species field guides) for providing additional information on this group of birds. It is conveniently sized to carry in the field and will be especially useful in sorting out look-alikes such as Hoary and Common redpolls. It provides carefully organized and well-presented information to those who wish to learn more about these birds than is given in the typical field guide. This is the type of book that makes a most welcome present!

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Wheatears of Palaearctic: Ecology, Behaviour and Evolution of the Genus *Oenanthe*

By E. N. Panov. Pensoft, Sofia, Moscow. 439 pages, U.S. $167.50

Wheatears are the quintessential Afro-Eurasian bird. Found anywhere there is open ground, the more desolate the better, wheatears make ideal subjects for ornithological study; indeed, according to the author they are among the most studied groups of passerines. They are easy to see and follow, they exhibit interesting behaviours, and, as a group, pose many riddles. How can up to four species with seemingly identical foraging behaviours co-exist in a relatively inhospitable habitat? Why in some species is there high sexual dimorphism and in others virtually none? What light can this group renowned for intra-species variation shed on the nature of polymorphism and its evolutionary origins? What are the advantages of a contrasty black and white plumage? How did one species of this desert loving family break through the oh so inhospitable for wheatears boreal forest to successfully colonize much of the Arctic including not once but twice in North America?

These and other questions are copiously answered in this book by E. N. Panov, a Russian scientist with a passion for this intriguing group. The book is divided into two parts, the first dealing with general features of wheatear biology, the latter providing detailed monographs on individual species or superspecies found in Eurasia. Between them, these sections cover every conceivable angle on wheatears, from the geographic distribution and origins of the group in its entirety through habitats, movements, social behaviour, reproductive behaviour to predators and parasites. Each monograph follows a template covering systematics, distribution, behaviour, nesting, and movements. The book is extensively illustrated with black and white sketches illustrating everything from behaviours, nest sites to plumage variations and is amply provided with sonograms, family trees, graphs and maps illustrating key points. There is also a section of 40 colour plates showcasing the array of arid habitats so beloved of the genus, portraits of selected species, and at least one picture of one being devoured by a snake. The book closes with a 14-page bibliography and an index helpfully divided into a general subject index as well as an index of animal names.

There are about twenty species of wheatear, with the exact number hard to pinpoint because of blurry lines with other turdidae such as saxicola ("stonechats") and uncertainty about the taxonomy of several closely related taxa. Taxonomic and genetic evidence suggests that the genus had its origins in Africa, where it may have emerged from an ancestor shared with redstarts. The large amount of variation and frequent contact zones within the genus suggest that there is an ongoing evolutionary process. The English name, which comes from the old English for white rump,

refers to the bold white "T" pattern which is characteristic of many members of the genus. Its Russian name, Kamenka, refers to the stony habitat they so love; their ability to cope with extreme conditions is witnessed by the fact for some 160 000 square kilometres in the Sahara the White-crowned Black Wheatear is the only breeding passerine, and the fact that the Northern Wheatear has successfully colonized arctic tundra. Given the lack of culinary choice their dietary habitats are pretty well catch as catch can; recorded food items include scorpions and bumblebees.

The Northern Wheatear, the only member of the genus in North America, is remarkable. Each year birds from Alaska, in the words of the author, "stubbornly make for their remote African homeland", an epic voyage that would exhaust an Arctic Tern. Birds nesting in Eastern Canada head in the opposite direction, and are the only Canadian passerine that winters in Africa. Being found in places where lots of ornithologists live; the Northern Wheatear is one of the better known members of the group. From these studies, we know that they maintain a frenetic lifestyle during the breeding season that can, in the far north, involve a 24/7 routine of zealously patrolling its borders while attending the needs of two females in widely separated territories. According to Panov, Wheatears are highly aggressive with a "low threshold for territorial aggression". To communicate with one another they have three different song groups and a remarkably varied repertoire of physical signals involving different postures and movements. The author also usefully informs us that they have an unpleasant taste, evidenced by experiments in which hornets were offered wheatear "meat".

It is disappointing that the author, demonstrably a competent illustrator and photographer, did not choose to include a series of systemic plates illustrating the various taxa and their variations. Another disappointment is that the author focused the species accounts on Eurasian taxa; one suspects that this reflects the author's research interests but also the fact that African taxa are relatively less well known. In the review copy the hatching on many of the maps was blurry, making them hard to figure out. Nonetheless, there are few errors in the book, although the fact that the title contains a grammatical error did not inspire much up front confidence.

This book is a scientific monograph primarily aimed at ornithologists. It poses, and proposes answers to a number of interesting ecological and behavioural questions and will be of great interest to anyone intrigued by evolutionary biology.

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BOTANY

Giant Trees of Western America and the World

By Al Carder. 2006. Harbour Publishing Co., Madeira Park, British Columbia. 138 pages. $18.05.

Al Carder has been researching giant trees for a lot of his long career, collecting stories of large trees in the Pacific forest of North America, his home and main study area. This book is a sequel to his earlier work trying to record the dimensions of many of the world's largest trees now including more facts and more tree species. The book is ordered by continents and tree families to give the reader perspective of the variety of trees which have achieved huge dimensions, but many of which have disappeared in the past century.

A short anecdotal essay at the beginning puts Carder's agenda forward quickly. He has always been awestruck by the beauty and perspective of being among the largest trees and wants to preserve the memory of those trees for future ages. Sadly the largest specimens of any tree species are gone from our world due to commercial logging in the last two centuries and when single giant trees survived the logging, these succumbed to windstorms, having been left without the surrounding forests which protected and supported their growth over the centuries. In North America, Australia and New Zealand, the story of logging is the history of large trees and our most impressive forests, a history which has more to do with destruction of forests than the story of humans interacting with their environment.

The book is short with only one hundred and thirty pages devoted to describing the trees. Each tree description has an accompanying page with a diagram of the tree at its largest reported size and shape, each species being unique in shape. Fifty of those pages are devoted to the trees of North America with the other pages listing and describing the outstanding trees of other continents. North America is obviously Carder's first priority but his love of trees encompasses the entire world.

Many trees in England and Europe have been available for study to written history over the centuries and Carder has researched these written accounts to give us historical anecdotes from their long life. A Tule tree in Mexico with an opening in the trunk large enough to accommodate twelve horsemen when reported 375 years ago, and the Sweet Chestnut in Sicily whose spread of branches sheltered the Queen of Aragon and her escort of 100 horsemen over 600 years ago are two of the anecdotes which describe trees still standing. Whether the tree has records of growing to over 400 feet as the Douglas Fir or whether its claim is to have lived over 5000 years as the English Yew, the grandeur of the trees is given to us by Carder to

be considered, enjoyed and lamented as phenomena which have existed but sometimes passed us by.

I enjoyed reading about present and past giant trees and was entertained different times looking for interesting facts and diagrams. It is not a book to be read at one sitting, even though short, because the tree species stand alone and reading several is like reading a list which can go on too long. A short reading of one or two tree descriptions at each visit is sufficient with another few minutes reading the next descriptions at another time. Soon the book becomes a reference for tree species and musings of how much we have missed and what we might visit. I have shown it to my students and they spent time with it as a picture and description book to browse and marvel. Al Carder has given us a little gem of knowledge and history for entertainment based on good science and research.

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ENVIRONMENT

Fire and Avian Ecology in North America – Studies in Avian Biology Number 30

Edited by Victoria A. Saab and Hugh D.W. Powell. 2005. Cooper Ornithological Society. 193 pages.

This technical work is a collection of 11 papers, ten of which address the role and effect of fire in one or more ecosystems (e.g., Boreal Forest, Oak Woodlands, Interior Chaparral); the first chapter is a cogent summary of the ten others.

The chapters more or less follow a logical pattern in their layout. Each paper shows a map of the distribution of the habitat(s) discussed, and normally one or two other figures. A table of pertinent literature is presented in each chapter, which also includes responses to fire of a number of bird species. The papers describe historic fire regimes, including the use of fire by aboriginals, as well as the effect of fire suppression on birds (and by default, the plants making up the habitat for them); sections on conservation strategies, including the use of prescribed burns and withholding of fire suppression end each chapter.

The only irritant to me was lumping all the references at the end of the book; normally, each paper should be concluded with its own collection of references. Should someone want to photocopy one chapter, they would have to photocopy the entire compilation of references, instead of just the pertinent ones. Nonethe-less, it is a solid work.

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Fisheries Assessment and Management in Data-Limited Situations

Edited by G. H. Kruse, V. F. Gallucci, D. E. Hay, R. I. Perry, R. M. Peterman, T. C. Shirley, P. D. Spencer, B. Wilson, and, D. Woodby. 2005. Alaska Sea Grant, Fairbanks, Alaska. Publication Number: AK-SG-05-02. 958 pages. Price: $50.00 US, ISBN:156612-093-4.

Maintaining sustainable fisheries resources requires the combined efforts of scientists, fisheries managers and policy makers. Balancing fisheries growth and conservation is a difficult task, particularly in situations where available information is limited. Data-limited fisheries are often plagued by a lack of long-term data on the basic biology, ecology and productivity of the species that are relevant to these resources. A number of successful fisheries have been developed by combining a scientific background with robust policy management to successfully develop sustainable fisheries, even in situations where data is limited. However, newly developing and small-scale fisheries often operate without sufficient data to develop production models, assessment techniques and sustainable management strategies.

To address these challenges, a symposium entitled "Assessment and Management of New and Developed Fisheries in Data-limited Situations" was held in Anchorage, Alaska, in 2003. The purpose of this symposium was to share knowledge, research and management strategies for newly developing and small-scale fisheries by bringing together fisheries scientists, managers and policy makers from all over the world. The result is a proceedings book titled "Fisheries Assessment and Management in Data-limited Situations." Specifically, this book is a collection of forty-six peer-reviewed research papers that provide case studies and management considerations for fisheries with limited data. The book is divided into seven sections: (1) case studies of fishery failures and successes; (2) indicators of stock health and productivity from limited sampling programs; (3) involvement of fishermen and use of local knowledge; (4) multi-species and ecosystem indicators and models; (5) precautionary management approaches; (6) stock assessment models; and (7) stock assessment surveys and applications. The first two sections focus on science-based assessments of fishery case studies while the final five sections identify and discuss management and assessment strategies. Throughout many of the case studies in this book, several key management themes emerge that are highly relevant to fisheries managers in data-limited situations.

Section one provides insight into the failures and successes of the world's fisheries. Several case studies on a variety of species are described, and management implications are discussed. A key paper in this sec-

tion provides a general overview of the world status of data-limited fisheries using landings statistics with a Bayesian approach (Vasconcellos and Cochrane). Each of the subsequent case studies describes techniques for managing both struggling and successful fisheries. These case studies focus on the development of new or developed fisheries that have limited data (Bechtol and Trowbridge; Bureau and Hand; Therriault et al.) and the recovery and management of struggling resources (Bargmann et al.; Kruse et al.; Stephenson and Jackson). Despite their geographically and species-specific nature, the general knowledge contributed by these case studies may be highly relevant to similar fisheries in data-limited situations in other parts of the world.

The second section focuses on developing indicators of stock health and productivity from limited data sets. Each paper describes a case study where early warning signs can be detected in order to predict the state of fisheries resources. The indicators that are described include biological indicators (LeBlanc et al.; Tribuzio et al.), performance indicators and stock dynamics (Hay et al.; Orensanz; Raid et al.; Ziegler et al.) and management indicators (Howland and Tallman; Scandol; Weyl et al.). A key paper from this section is a simulated study of Yellowfin Bream (*Acanthopagrus australis*) where empirical stock-status indicators were assessed using quality control methods (Scandol).

The third section focuses on the integration of local fishermen and traditional ecological knowledge in fisheries management. A key paper in this section by Freire describes the use of data provided by anglers in the assessment of Brazil's growing recreational fisheries industry. This paper represents the first data of their kind from South America and illustrates the potential value of recreational anglers as a key data source for improving fisheries management in data-limited situations. The fourth section contains papers that are geared towards the assessment of the effects of fisheries at the ecosystem level by using ecosystem indicators (Stobberup et al.) or models (Ainsworth and Pitcher; Cheung and Pitcher; Morato and Pitcher). This section contains an interesting study by Cheung and Pitcher that outlines possible strategies for evaluating fisheries management policies that aim to conserve biodiversity. The fifth section contains a number of studies that take a precautionary approach to data-limited fisheries management. The majority of the studies in this section focus on fisheries uncertainty (A'mar and Punt; Campbell and Dowling; Punt and Methot; Welch; Zheng). One key paper involves an evaluation of a multi-stage approach to data-limited fisheries management. Perry et al. assesses the four-stage approach to new and developing fisheries (i.e., data collection, design of key studies, implementation of selected strategies and establishment of the new fishery) designed by Fisheries and Oceans Canada. One of the most challenging factors in this staged framework, as with the management of many of the world's fisheries, is the contradiction between the demands of access to fisheries and the conservation of these resources. This paper addresses some key points that are relevant to balancing these challenges.

The sixth section contains several papers that address the use of models in stock assessment. Stock assessment bias and sensitivity are addressed by two key papers in this section (Ernst and Valero; Mesnil). Also, Catch-Survey Analysis (CSA) is discussed by two papers to estimate stock abundance (Collie et al.) and to address concerns over sensitivity and bias (Mesnil). Similarly, the seventh section addresses stock assessment methods and surveys. In this section, several key methods are described, including population density assessments using scuba (Byerly and Bechtol) and the applications of acoustical estimations (Kaljuste et al.). This section also addresses sampling designs for estimating bycatch (Menon et al.), methods for accounting for climate variability in models (Shotwell) and assessments to address concerns over recreational overharvesting (Therriault and Hay). A case study discussing the modeling of climate variability in relation to forecasting Pacific salmon spawner-recruit dynamics (Shotwell et al.) is particularly relevant to data-limited fisheries that require the input of variable environmental data into forecast models.

This book contains an excellent assemblage of well-written, highly relevant research papers on data-limited fisheries. Several management themes emerge from this book, including (1) the development of key rapid assessment tools, (2) the integration of traditional knowledge from fishermen and local ecological knowledge, (3) the adoption of a precautionary approach to fisheries management, (4) the evaluation of sensitivity and bias in stock assessment models, and (5) the development of robust stock assessment methods. These key strategies recur throughout many of these studies and are relevant to fisheries worldwide. Further, several novel strategies for managing data-limited fisheries are discussed, including the development of key modeling and assessment tools. This book offers one of the first attempts to assemble key literature on data-limited fisheries into a single volume. This is an invaluable resource for the management of new or developing fisheries.

The intention of this collection is to provide scientific background to new and developing fisheries. Each research paper attempts to suggest applications of their case study to other similar data-limited fisheries resources. However, the seven sections contained in the book are organized with little or no preface or interpretation of this research. Throughout the book, the links between the results of each case study to a broader application are often tenuous. For most proceedings books in this style, it is common to omit interpretations by the authors or editors in each section. However, the nature of this research demands a synopsis in each section to highlight the applications and extensions of this research. Managers require the interpretation of fisheries experts who are experienced with data-limited

situations to identify how the methods described in this book can be applied to their own data-limited situations. In summary, the management themes that emerge from this collection are highly relevant to all fisheries managers, policy makers and scientists working with data-limited fisheries. However, this book would be considerably more useful to these stakeholders if the context of each section was clearly described in a one to two page preface and synopsis summary that outlines how this knowledge could be applied in practice.

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Lapland – A Natural History

By D. Redcliff. 2006. Yale University Press, P.O. Box 209040, New Haven, Connecticut 06520-9040. 352 pages, U.S. $60. Cloth.

Lapland: a Natural History by the late Derek Redcliff, is a remarkable account of the birds and higher plants of northern Scandinavia. This book begins with a general description in land use and the geological background terms followed by a skillful history of the earlier naturalist visitors. The book is mainly given over to a detailed evaluation of the various habitats found in this area. These include Boreal Forests, Forest Peatlands, Lakes and Rivers, Coastlands, Tundra and Man-influenced habitats. Each of these chapters is divided into vegetation and flora and birds. The birds section is subdivided into key groups such as wildfowl, waders (shorebirds), birds of prey, songbirds and birds that are of particular importance in that habitat (e.g., wildfowl or grouse).

The author writes in a style reminiscent of a professor giving a lecture to keen students and as a result the book is easy and pleasant to read. The accounts are packed with information drawn from many research sources, backed up by the author's own observations. The text does contain references, but not in sufficient number to impede the flow of ideas. Every few pages there are four half-page photos. These depict habitats, plants, birds and bird nests. Particularly impressive are the almost two dozen photos of shorebird nests (have you ever tried to find a shorebird nest?). These photos, most by the author, are of very fine quality. Interspersed with the text are some engaging black-and-white illustrations by Mike Unwin, reminiscent of those in the journal, *British Birds*.

I particularly enjoyed the way Redcliff linked the occurrence of a species with the other components of the habitat. He does a wonderful job of showing the inter-dependance of each constituent of a habitat and the consequences of disruptions to the balance, both natural and man-induced.

Even though I found this a treasure trove of information (and wisdom) I did have several problems. I hoped, while doing this review, I could compare the plant life of Northern Canada, Svalbard and Lapland. The author's inconsistent use of scientific names became a source of frustration for making this comparison. The worst case was his discussions of Dwarf Azalea. As he does not include the scientific name it is hard to be sure which plant he is referring to. Lapland Rosebay (Canada) or Lapland Rhododendron (Europe) is *Rhododendron lapponica*, but the author quotes this plant separately. Indeed, he includes a beautiful photo of this lovely plant. He also includes a photo of "Dwarf Azalea", but it is a very un-Rhododendron-like plant (more like a saxifrage or even Moss Campion). After much searching and consultation with Bill Cody (author of several books etc. on northern plants) I was still unclear until I found a reference to *Loiseleuria procumbens* as Trailing Azalea (and several other English names) while identifying plants from Cambridge Bay, Nunavut. Similarly I was never sure if the Finnmark Primrose was the same as *Primula erects* or *nutans* or if it was a new species or subspecies.

Also the book only covers the higher plants well. There is relatively scant mention of the lichens and other more primitive plants. I am sure that there must be well over 500 species of lichens in this area, yet the book refers to only a handful. Other groups are even more poorly represented. On the animal side, birds are well covered. Mammals get an introduction and other groups (reptiles, amphibians, butterflies and dragonflies) get an honourable mention. Other wildlife such as beetles and bugs do not get any attention.

I also had problems with many of Redcliff's terms. To start with, he does not really define what he means by Lapland, Fennoscandia, Fennoscandinavia and Scandinavia. As he uses terms like "Southern Lapland", I felt it important to understand the region's precise location. His map showing the location is vague so I thought I would check further. Lapland is somewhat well defined (northern Norway, Sweden, Finland and Russia – or the home of the Sami). Actually I have found Finnmark, Nordland, Nord-Trøndelag and Troms [counties of Norway], Lapland [a province of Finland], Jämtlands Län, Norrbottens Län and Västerbottens Län [counties of Sweden], and Murmansk [an oblast – or "province" – of Russia] form Lapland. Knowing at least where the county of Finnmark is located is most useful when reading the text. However, the other terms vary from source to source. They could include some or all of Norway, Sweden, Denmark, Finland, Iceland and the Faeroes. Similarly I had trouble with the terms flark, fell, strang, patterned fen and mire. Eventually I did get them sorted out but a glossary would have been so helpful.

I have several problems with the index. First, it does not reference any scientific names, only English ones. None of the photos are listed. Some of the entries are

listed forward (e.g., Lapland Rhododendron and Alpine Lady Fern) and some entries are listed backward (e.g., Primrose, Finnmark and Birch, Downy) making it difficult to decide which letter to use.

The author includes range maps from other sources. The maps for plants use the scientific names (If you did not know *Silene acaulis* is a Moss Campion [as opposed to the synonyms: *Silene bryoides, Silene exscapa*] you would be a little lost. The lovely photo of *Parmelia centrifuga* is not identified as a concentric ring lichen). The map captions for birds use English names. The maps are not in the index.

The Three-toed Woodpecker was split in 2003 into the American Three-toed (*Picoides dorsalis*) and Eurasian Three-toed woodpeckers (*Picoides tridactylus*) using differences in mitochondrial DNA sequences. The author has not mentioned this or any other recent splits. Perhaps this is not as significant a issue in a book focused on ecology rather than identification.

Finally, the book contains two photos of people; one is the author, although the caption omits this detail and the other is Jeanette. The book is dedicated to this lady, but her presence is never explained (she is Mrs. Redcliff).

This is a great book for anyone interested in the far north or who wants to understand the complexities of life. It is wonderful and fascinating reading if you are passionate about natural history, but is of more limited value for research.

Derek Redcliffe was the first to establish the role of agricultural pesticides with the decline of birds of prey. He was chief scientist of the Nature Conservancy Council in the UK where he acted as a scientist and lobbyist for nature conservation. He fearlessly attacked and changed agricultural and forestry interests for the damage to wildlife value caused by their policies and practices in place at the time. Not an easy or popular task in Maggie Thatcher's world. Despite his legendary contribution to UK conservation he was denied any honour by the state – in a country that knights pop stars. Redcliff was known an extraordinary naturalist, good company and friend. His last book is a fitting legacy.

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Fish, Fur and Feathers: Fish and Wildlife Conservation in Alberta, 1905-2005

Fish and Wildlife Historical Society. Federation of Alberta Naturalists (FAN), Edmonton. $39.50, 418 pages.

This sumptuous, well-illustrated book is an eclectic mix of articles, reminiscences and interviews. The main text is on white paper, and the other contributions on yellowish paper. Only rarely does this confuse the reader but the white paper portion of chapter four ends in the middle of an incomplete sentence.

As expected with any product of a committee, some chapters are stronger than others. We often know who wrote a particular piece, but sometimes we don't. Nowhere, not even at the end of the two-page Editor's Note, are we told the name of the chief editor (Bill Wishart, as I learned from a special enquiry to Edmonton). At the end of each chapter are references and a useful chronological list of the main happenings.

In Alberta, as elsewhere, the responsibility for fish and wildlife management grew from a handful of voluntary game guardians to a diverse group of biologists and enforcement officers within professional, academic, and conservation communities. Yet for the better part of a century the emphasis was on fishing and hunting. In 1967 the first female biologist (now the president of the Canadian Medical Association) was hired, and only in 1987 was the first non-game biologist hired. Now there are 14 recovery teams developing and implementing plans for threatened and endangered species.

Some accounts are superb. The account of the change in upland game numbers associated with harvesting practices, from threshing machines, grain separators, and wheat stooks to combine harvesters, is among the best I have encountered.

Alberta has had some unique successes. The Peregrine Falcon restoration program, under the direction of Richard Fyfe, was immensely important. One week in the 1960s, biologists taught a three- or four-evening short course in wildlife biology and management, specially designed for Members of the Legislative Assembly; more than half of them attended! A M.Sc. thesis on the fish and wildlife damage inherent in the planned Highwood Dam helped to influence the shelving of that project.

Biographical information is generally excellent, giving credit to world leaders in biology, especially William Rowan. Even though this book is co-sponsored by the FAN, amateurs are somewhat slighted, except for Frank Farley, Cam and Joy Finlay, Elsie McAllister, Myrna Pearman, Dewey Soper, and Kerry Wood. Edgar Jones is barely mentioned and Otto Höhn, Robert Lister and Al Oeming are omitted. Information resulting from bird banding is provided only as regards waterfowl. The Beaverhills Bird Observatory is not indexed. The outstanding studies of Golden Eagle migration west of Calgary by Peter Sherrington, the landmark studies of Ferruginous Hawk biology by Josef Schmutz, and the northern owl banding by the Edmonton group are not mentioned.

The compilers are frank about some of the bureaucratic bungles ("bureaucracies are often much too shortsighted," page 207) and failures, such as legislation

drafted, but never proclaimed. The "biggest mistakes of the century" are identified as the transfer of diseased bison to Wood Buffalo Park, game farming, predator control attempts, "too many fishermen," and loss of habitat.

There are a few errors of fact and interpretation. The two-page account of the Prairie Farm Rehabilitation Administration is unusually misleading when it speaks of 87 community pastures by 1999, omitting the fact that only one (in three blocks within the Suffield Military Range) of these PFRA pastures is in Alberta. The American White Pelican was threatened, never endangered (page 341). Gary Pelchat was born in Ponteix, not the never-existent Phoenix, Saskatchewan. David Munro is misspelled "Munroe". The first two Franklin Arctic expeditions were hoping to find an arctic sea route, not an overland route to Asia. The index is inadequate, failing to index names of any organism (e.g., pronghorn, ring-necked pheasant, and liver fluke). For consistency, the book title might better have been *Fin, Fur and Feathers*.

With pressure from an increasing urban human population, highways, and mechanization of farming, mining, oil extraction, forestry, dams and irrigation, it will be difficult to maintain biodiversity in the decades to come. Some hope may be gained from looking at both the successes and failures of the past.

A large book, it is too heavy for bedside reading. Caveats aside, this is a wonderful collection of information that should be in all major Canadian libraries, and read by everyone interested in the history of fish and wildlife conservation and management.

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The Gulf of Alaska: Biology and Oceanography

By P. Mundy 2005. Alaska Sea Grant College Program, University of Alaska-Fairbanks, Edited by Exxon Valdez Oil Spill Trustee Council.

Alaska is perceived "...as a place of wilderness, beauty and a special way of life". This book describes the Gulf of Alaska (GOA), a region with many world records. Besides covering a huge area, having the third largest permanent ice field in the world and being a central place, crossroads, for almost all of the Pacific salmon, GOA also is among the most productive oceans in the world.

The introduction is a chapter on general oceanography for the lay public; the classic concept of the 'Conveyor Belt' is presented. Due to its ecological importance, I like the human footprint statement such as "Human uses of the GOA are extensive" and "... it is rare to walk the intertidal zone anywhere in GOA without seeing evidence of human activity". The "...marine pollution and floating refuse from as far away as Asia, or originating from deliberate deep-ocean dumping or accidents at sea, can be swept north and westward around the shelf edge in the GOA. Trash from the international fishing industry operating 200 miles offshore is commonly found on beaches". Further, one will read that GOA has arguably the best known rocky tidal zone on earth, and this small tidal zone is crucial for the ocean. This book admits climate change but leaves it somewhat undefined whether it is a man-made issue, or not.

The book contributors emphasize that to fully understand the ecology of GOA first one needs to make an effort to identify of all relevant species, e.g., plankton. Shrimp, once among the dominant benthic epifauna in Lower Cook Inlet, Kodiak and along the Alaskan Peninsula, declined after maximum harvests in 1977, and today its fishery is virtually nonexistent. Red King Crab crashed in 1980, and Tanner Crab fisheries are down as well. The clam fishery in Cordova never recovered from damages brought by an earthquake. Despite its fishery of global importance, the two short paragraphs for the Pacific Cod section are rather uninformative. The fisheries for Walleye Pollock have been down since 1982. The Herring loss story for Seldovia Bay and Lower Cook Inlet is reported on as well. Salmon from Japan, Russia, British Columbia, all of Alaska and the Pacific North West spend some part of their life cycle in the GOA. The canned salmon industry collapsed in 1959, the year when Alaska became a U.S. state.

Despite all of this overwhelming evidences of limited ocean supplies, some book contributors still claim in their chapters the traditional views of "unlimited resources". Other sections blame the "stocks" and anglers for their impacts (rather than their managers with a governmental mandate for safeguarding the public resource). Fortunately, sea floor dredging effects are explained, since fishery impacts to the soft-bottom benthic community are a possible driver of community change. It is suggested in the book text that this affects Steller Sea Lions as well.

Throughout, the book shows that for non-commercial species we lack management information. These species compose the bulk of the biomass. By-catch of the juvenile cohort occurs in fisheries like Herring, Pollock, and Salmon. However, for many of the non-commercial species the magnitude of this phenomenon is not really known, nor how much it affects these stocks.

Even apart from all of these severe marine issues mentioned in the book, the described terrestrial situation is equally puzzling: The book states that in the GOA, 24% of the water bodies listed are on the state's list of polluted sites attributed to some aspect of logging.

The book makes clear that Alaskan "Subsistence Harvest" is a much-debated issue, a major political player in Alaska and beyond, and thus, well supported by the government. However, only 2200 people in the Exxon Valdez Oil Spill (EVOS) region actually still practice this form of life style. This must be among the most subsidized lifestyles in the world. The government uses undercover agents to report on how much natural resources are taken.

How much do Alaskans value their nature? This book provides an answer: Anchorage operates under a Clean Water Act Section waiver, only completing primary treatment of the sewage. The classic cocktail of PCB, DDE, DDT and Dioxin gets named several times, but there are many more pollutants in the Arctic. The complex toxic pollution of the Copper River is mentioned though. I think that most readers will get excited that the Alaskan government does not choose to monitor for environmental pollutants.

A seabird chapter deals with nesting species, not with its pelagic, non-breeding populations. Cliff nesting murres and Black Kittiwakes are the most well studied; underground and nocturnal species are hardly known. The statements "There is no evidence that seabirds in the GOA have been directly affected by commercial fisheries" and " ...do not compete with commercial fisheries for biomass" give the wrong impression. The book publishers need to be chastised for this misleading statement as it sets the stage for inappropriate environmental management policies in favour of economic activities.

Seabird starvations in GOA are mentioned several times; e.g., related to climatic ENSO (El Niño/Southern Oscillation) events. There is nice documentation of increased gull predation e.g., Glaucous-winged Gulls on Black-legged Kittiwakes, due to increased gull populations. The given Marbled Murrelet estimate of 200 000 nesting birds is likely low when compared with the authoritative literature. The provided nesting seabird population table is misleading since non-breeders occur in the region and thus, populations are higher.

The Minerals Management Services, EVOS, NMFS (National Marine Fisheries Service), and the Alyeska Consortium did extensive benthos survey and monitoring efforts in GOA in the 1970s. The reader is left wondering where these raw data are and this book does not help us to learn where to find them. One simply has to trust the "experts" blindly. This must set the stage for conflict.

The contaminant issue I find not well handled in this book either, considering that EVOS was a GOA event of global attention and recognition. Since this book is an EVOS publication one has to ask, what did we really learn from EVOS? There is no chapter devoted to toxicology or sections contributed by a professional Alaskan toxicologist. One will have a hard time to find much oil spill literature. At least we know, in 2000, 604 spills were reported in the EVOS GOA region alone, proving we do have an oil and hazardous substances problem.

The book notes that there is a conflict between increasing development and loss of environmental quality in the GOA region (as found anywhere else in the world). Rats, ground squirrels and voles introduced in most of the Aleutians between 1700 and the 1900s make for a great example. Other examples include fox farms starting 1894 onwards, followed by canneries, the Klondike Goldrush of 1897, a copper mine operated from 1905 and the Northwestern railway built in 1911.

Marine mammals are elaborated on in greater detail: seal decline in 1973-2000 and the sea lion decline of approximately 83% (maybe >90%). The federal funding for investigating this sea lion decline is between 40 to 60 Million $$; a record in federal spending on one species. Was it a success?

The infamous Killer Whale story and their blame for the seal decline gets featured as well; e.g., in Prince William Sound, Killer Whales consume 400 seals each year (somebody has to eat the individuals of poor health; sharks were suggested as well). Killer Whales are believed to have suffered through EVOS.

Ecologists might be happy to see that the textbook example of how Sea Otters and their over-harvest links with Sea Urchin and kelp populations is mentioned. The book reports that lead in Sea Otters can now be traced directly to industrial sources, namely from North America and Asia, which makes for a great example for the need of international management in GOA (none of this is demanded in the book text though).

Overall, it remains unclear to me what the exact focus of this book is, and why it was published. Readers must see it as a major oversight that no professional contacts and addresses are provided for the 13 contributors or even editors. I found the content editing sometimes poor and not well structured. This becomes obvious in the multiple mentioning of the study area and its repetitive definitions and maps throughout chapters. Some of the chapter sub-headings are virtually similar to the chapter heading, other sub-headings and themes re-occur in other chapters. The quality and amount of citations varies throughout chapters. I like the abbreviation and acronym section because it also includes websites and their URLs. Some of the figures are stunningly made, but unfortunately in black and white.

It becomes quickly obvious that in concert with the many other signs and evidences there is something wrong with the natural state of GOA, and subsequently how it is managed. This book is a great example how unpublished and non-peer reviewed grey literature can rather add to confusion and is not achieving its goals for sustainable management.

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MISCELLANEOUS

Fossil Legends of the First Americans

By Adrienne Mayor. 2005 Princeton University Press, Princeton, New Jersey, USA. 446 pages. illustrated.

The lure of fossils is not a recent venture. For centuries, by accident or pursuit, "sports of nature" as they once were called have fascinated our cultures. Yet, while fossils rose from "sports" to conceptions of the organic past, this was essentially a western perspective, shaped by culture and scientific advancements. It is a little surprise, however, that the North American aboriginals or First Nations people were also drawn to these pieces of the past. The reasons varied, to be sure, but hidden to us were concepts of evolution and a sense of deep time. It is a great fortune that author Adrienne Mayor has investigated and recorded this diversity of cultures, much of it based on the oral, not written, tradition, and to some extent existing in various artifacts.

Mayor's first foray into fossil lore and history was *The First Fossils Hunters, Paleontology in Greek and Roman Times* (2000) which examined Greek and Roman period and place with respect to fossils. Of course these cultures are rich in textual artifacts and documentation, and were in essence at the root of western civilization. Mayor's recent study, *Fossil Legends of the First Americans*, is somewhat more of a challenge. As part of paleontological lore, aboriginal communities certainly had contact with fossils but to what extent? Lacking written tradition, painted in broad strokes, and compounded by our interpretation of their awareness, what were their concepts of "deep time", extinction, or even a notion of evolution?

Mayor argues that aboriginals had more than a cursory view of fossils, and in many respects, and with a much finer, multi-colored strokes particular to specific groups, their views are much richer than anyone expected. By reviewing cultures from south to north, each North American culture ebbed and flowed territorially, originating or modifying concepts of their surroundings and to some degree of the fossil bones and stones encountered. Some Navajos in the southwest United States, for example, believe that it is horrific to disturb buried bones. "The Navajos envisioned a series of past worlds that were destroyed before this world" says Mayor, each with good and evil monsters. By digging them up, the fear emerges of bringing these past monsters to our world. The large fossils found in the Navajo territory bespeak of life of great size in the form of petrified logs from the Petrified Forest National Park in Arizona, and of other possibilities in the rich, paleontological nest that they could have come across. This is more than mere tales of monsters.

Fossils were not always considered dire by those who came across them. "Rock medicine of the Crows and their traditional enemies, the Sioux, often included unusual fossils, especially ammonites and baculites" (page 268). They believed that these fossils carried with them mystical powers. In Alberta, medicine pouches of the Blackfeet often carried "buffalo-calling stones", which are the segmented portions of a Cretaceous baculite that look the shape, in cross section, of a buffalo. Aboriginals even attach some significance to the esthetics of fossil-bearing rock, in one case a point made of Pennsylvanian-age rock containing the ornate designs of the single- celled marine fusulinids from Kansas.

Throughout Mayor's work she references the revered paleontologist the late George Gaylord Simpson (1902-1984). Like the few earlier records of ethnology and paleontology, Simpson is often taken to task for his forays into the history of fossil collecting in North America. His definition of "discovery" was much narrower than Mayor's. He believed that "merely seeing a fossil bone or picking up an idle curiosity is hardly discovery" (1943, page 26). Therefore, Simpson gave little weight to beliefs and customs of First Nations people with regard to fossils in his reviews. He knew that there was contact with fossils, as in the case with the abundant fossils from the "Big Bone Lick" of the Ohio Valley, popular in the lore of American history as well as paleontology, but that's about it. Despite the fact that Simpson's views were reflective of 1940s American culture, Mayor's stance is that the discoveries "were not scientific in the modern sense, of course, but there is something akin to scientific inquiry in these activities" (page 29-30). Many of the aboriginal oral traditions were handed down from one generation to another, thus becoming a permanent record in their culture. This is one of the requisites of scientific tradition.

The 19th century American expansionism included vast paleontological initiatives like those seeded by Joseph Leidy (1823-1891), O. C. Marsh (1831-1899), and E. D. Cope (1840-1897). Ethnological initiatives also followed, but for some reason, cultural interpretation and fossils never met. Even when aboriginals were hired as scouts for the paleontologists, the "paleontologists ... [left] folklore to the ethnologists, so the ethnologists left paleontological topics out of their conversations with Native Americans" (page 195). As such, paleontological/ethnological information gathered today, some if recorded for the first time by Mayor, is tainted with over a 150 years of invading culture. A number of these aboriginal cultures have substituted their original, monstrous, interpretations of fossils with post-1840s terminology like "dinosaurs".

Where Mayor falls short, however, is in the extent of parallelism between aboriginal and western views of fossils and their meaning. There are a lot of "may have[s]", "could appear[s]" between the two views of scientific and cultural interpretation, and thus some of the interpretations seem somewhat forced. For example, an Assinoboine tale has "a great river monster" succumbing to a "violent death by the impact of a

"thunder stone", a black projectile that came whistling out of the west" at great speed and sound, "*a scenario that seems akin to the modern theory of an asteroid impact 65 million years ago*" (page 289; emphasis added). The implied connection is not tenable. Likely an interpretation of a meteor, the connection between the extinction of a group of species by an extraterrestrial object is a contemporary idea.

Fossil Legends of North American should have been written a century ago when contact with the First Nations people was still fresh. But the exploration of the cultural/science intertwining is still a relatively recent phenomenon. In this case, only a few other recent titles address fossils in a cultural context (see Cohen 2002; and to a lesser extent Semonin 2000). Still, if it were not for Mayor's effort, from documenting the oral traditions, the searching of archives, museums and journals, we would be left with a culturally insensitive, simpleton view of rich and diverse cultures and their varied, unique surroundings.

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A Field Guide to Gold, Gemstones & Mineral Sites of British Columbia, Sites Within a Day's Drive of Vancouver

By Rick Hudson, 2006. Volume 2 Revised Edition. Harbour Publishing Co. Ltd., P.O. Box 219, Madeira Park, British Columbia VON 2H0 Canada. 368 pages $26.95 Paper.

Rick Hudson has succeeded in expressing his passion for mineral collecting through his field guide book. On a second level he also tries to promote a sense of adventure by teasing the reader to go out and explore or prospect for nature's buried treasures.

The author structured the book so the reader can easily cross-reference required information in the lengthy location lists. A "How to use this Book" and a "Quick Reference Guide" helps to quickly locate items of interest throughout the book.

The book cover illustrates the hobby of mineral collecting as a family activity. Hudson educates the reader from first principles on how to become a rockhound. To accomplish this, he describes how to prepare yourself by choosing proper clothing, safety gear, collecting tools and maps. He warns the future mineral collector about natural hazards they may encounter such as rattlesnakes, grizzly bears and ticks. Ethics, access rights and mineral rights are also discussed to keep the collector within acceptable collecting practices and to avoid unintentional trespassing.

Mineral collecting is attractive to many people because as you find an interesting mineral specimen, you want to learn how nature created it and or its geological history. The author has included short geological descriptions partitioned by collecting areas as well as mining histories of local economic importance within the collecting area.

Colour plates illustrate the minerals found in some of the collecting sites and detailed occurrence maps are included in all the collecting area sections throughout the book. The colour plates represent minerals that are possible to find in the collecting sites. Government mineral index files were included in the locality information along with detailed road log descriptions.

The author has made a successful merger of personal knowledge and technical data to compile an informative volume which can provide years of enjoyment for many future rockhounds and their families and friends.

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NEW TITLES

†Available for review * Assigned

ZOOLOGY

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North American Mushrooms: A Field Guide to Edible and Inedible Fungi. By Dr. Orson Miller and Hope Miller. 2006. Globe Pequot Press, 246 Goose Lane, P.O. Box 480, Guilford, Connecticut 06437 USA. U.S.$25.95

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ENVIRONMENT

A Complete Guide to Arctic Wildlife. By R. Sale. 2006. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 400 pages. $49.95.

Wild Borneo. By Nick Garbutt and Cede Prudente. 2006. New Holland Publishers (UK) Ltd., Garfield House, 86 – 88 Edgware Road, London,W2 2EA United Kingdom. £29.99 Cloth.

* **Guide to Deserts.** Edited by A. Warren and T. Allan. 2006. Firefly Books Ltd., 66 Leek Crescent Richmond Hill, Ontario L4B 1H1 Canada. 240 pages. $19.95.

Ecological Nationalisms – Nature, Livelihoods, and Identities in South Asia. Edited by Gunnel Cederlof and K. Sivaramakrishnan. 2006. University of Washington Press, 1326 Fifth Avenue, Suite 555 Seattle, Washington 98101-2604 USA. US$50. Cloth.

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Endangered – Wildlife on the brink of extinction. By G. McGavin and D. Burnie. 2006. Firefly Books Ltd. 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 192 pages. $35.

Evolutionary Dynamics. By M. Nowak. 2006. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 312 pages. U.S.$35.

The Revenge of Gaia – Why the Earth is fighting back – and how we can still save humanity. By James Lovelock. 2006. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom. 177 pages. £16.99 Cloth.

Galapagos: A Natural History. By John Kricher. 2006. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN United Kingdom. US$19.95, £12.95. Paper.

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Field Guide to Gold Gemstones and Mineral Sites of BC – Volume 2 Revised Edition (Sites within a Day's Drive to Vancouver). By Rick Hudson. 2006. Harbour Publishing, 4437 Rondeview Road, Madeira Park, British Columbia V0N 2H0 Canada. 368 pages. $26.95

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The Man-Eaters of Eden: Life and Death in Kruger National Park. By Robert Frump. 2006. The Lyons Press, 246 Goose Lane, P.O. Box 480, Guilford, Connecticut 06437 USA. 272 pages. US$24.95 Cloth.

Western Newfoundland and Gros Morne National Park. By B. Bursey. 2006. Nimbus Publishing Ltd., 3731 Mackintosh Street, Box 9166, Halifax, Nova Scotia B3K 5M8 Canada. 88 pages. $22.95.

New Zealand – a natural history. By Tui De Roy and Mark Jones. 2006. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 160 pages. $40.

A View of the River. By L. Leopold. 2006. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 298 pages. US$19.95

† **States of Nature.** By Tina Loo. 2006. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2 Canada. 320 pages. $85 Cloth.

Southeast Asian Biodiversity in Crisis. By Navjot S Sodhi and Barry W Brook. 2006. Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU United Kingdom. £65.00 Cloth.

The Green Tiger – The Costs of Ecological Decline in the Philippines. By Barbara Goldoftas. 2006. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 264 pages. US$74 Cloth, US$24.95 Paper.

Vietnam: A Natural History. By Eleanor Jane Sterling, Martha Maud Hurley and Le Duc Minh. 2006. Yale University Press P.O. Box 209040, New Haven, Connecticut 06520-9040 USA. 448 pages. US$40 Cloth.

Waterfowl Ecology and Management – 2nd Edition. By G. Baldassarre and E. Bolen. 2006. Krieger Publishing P.O. Box 9542, Melbourne, Florida 32902-9542 USA. 580 pages. US$112.50.

† **Walk around the Pond.** By G. Walbauer. 2006. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 286 pages. US$22.95.

Wilderness Predators of the Rockies – The Bond Between Predator and Prey. By Mike Lapinski. 2006. Falcon Guide, 246 Goose Lane, P.O. Box 480, Guilford, Connecticut 06437 USA. 208 pages. U.S. $17.95 Paperback

The World's Wild Places. By C. Prior. 2006. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 224 pages. $49.95.

News and Comment

Ontario Natural Heritage Information Centre Science and Information Newsletter 11(1) Winter 2006

Contents of this 20-page issue: FEATURE ARTICLE: Transferring conservation science to practitioners — 2005 PROGRAM HIGHLIGHTS: Plant communities of Ontario upper great lake marshes — NHIC to track rare disjunct arctic-alpine plants — 2005 species at risk field survey highlights — Rare plant surveys of Long Point region — Natural spaces program — Mapping species at risk with biotics — Two major dragonfly meetings in Ontario — 2005 PROJECT HIGHLIGHTS: NHIC launches Ontario Odonata atlas website — Aquatic species database — Great Lakes islands conservation blueprint — Lichen biodiversity project — NEWS AND NOTES: Summer experience program at the NHIC — Ontario eastern habitat joint venture — GIS Project — Eastern region Natureserve conference — NHIC data supports the assessment of species of global conservation concern in Canada — NHIC joins new biodiversity section of MNR — Publication notices — NHIC staff information.

Mailing address for Natural Heritage Information Centre, Ontario Ministry of Natural Resources, 300 Water Street, 2nd Floor, North Tower, P.O. Box 7000, Peterborough, Ontario K9J 8M5, Canada; www.nhic.mnr.gov.on.ca/MNR/nhic.cfm.

Marine Turtle Newsletter (111)

January 2006. 28 pages: EDITORIAL: Does the Mediterranean Green Turtle exist? (N. Mrosovsky) — Comment on the guest editorial by Paul J. Ferraro (P.C.H. Pritchard) — Response to Comment by Peter C. H. Pritchard (P. J. Ferraro — ARTICLES: Report on long-term transmitter harness retention by a Leatherback Turtle (S. Dowling, R. Solano, A. Diaz-Merry, J. Ordonez, J. Taylor, D. R. Evans, D. Godfrey, D. Bagley, L. Ehrhart, and S. Eckert — Marine Turtles on the Southern Coast of Bioko Island (Gulf of Guinea, Africa), 2001-2005 (H. Rader, M. A. E. Mba, W. Morra, and G. Hearn — Incidental capture of marine turtles in Marine fisheries of southern Spain (J. C. Baez, J. A. Camidax, and L. Rueda — First evidence of Leatherback movement from Africa to South America (A. Billes, J. Fretey B. Verhage, B. Huijbregts, B. Giffoni, L. Prosdocimi, D. A. Albareda, J.-Y Georges, and M. Tiwari — NOTES: *Charybdlis hellerii*, a non-indigenous portunid crab from the gastrointestinal contents of a Kemp's Ridley Sea Turtle (*Lepidochelys Kempi*) in Georgia, USA (M. Frick and K. Williams) — An update on Eritrea's marine turtle programme and first record of Olive Ridley turtle nesting in the Red Sea (n. Pilcher, S. Mahmud, S. Howe, Y. Teclemariam, S. Weldeyohannes, T.Menggsu, and M. Giotom — Epibionts associated with *Chelonia mydas* from northern Brazil (S. Pereira, E. H. S. M. Lima. L. Ernesto, H. Mathews, and A. Ventura — Small Leatherback found in Dominica (R. Byrne and S. A. Eckert) —MTSG UPDATE — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

Wildlife Afield 2(1,2)

A British Columbia semi-annual publication (ISSN 1712-2880) published by The Biodiversity Centre for Wildlife Studies twice a year. Additional information at www.wildlifebc.org.

Volume 2, Number 1, contains FROM THE EDITOR: Spinning a web — On the covers — FEATURE ARTICLES: Migratory occurrence and status of select shorebirds in the vicinity of Fort St. John, British Columbia (Chris Siddle) — Survey of Painted Turtles in the Creston Valley, British Columbia, in 2003 and 2004 (Linda M.Van Damme) — NOTES: Changing status of Ring-necked Ducks wintering on Salt Spring Island, British Columbia, 1978-2004 (Robert B. Weeden — Barred Owl feeds on Ban-tailed Pigeon (David C. Schultz) — First winter occurrences of the Cape May Warbler for British Columbia (Phil Ranson) — Burdock entrapment of a Ruby-crowned Kinglet in the Creston Valley — First nest and eggs the Canada Warbler for British Columbia (R. Wayne Campbell) — Pinyon Jay (*Gymnorhinus cyanocephalus*): A new species for British Columbia (Kim Asquith and Malcolm Dennington) — Incidences of Gopher Snake predation in bluebird nest boxes — Unsuccessful nesting attempt of Black-necked Stilt in British Columbia (Ryan Tomlinson) — Status of the Rock Pigeon (*Columba livia*) in Nelson, British Columbia (Janice E. Arndt) — WILDLIFE DATA CENTRE: Featured species — Thinhorn Sheep (Fred L. Bunnell) — Report of the Wildlife Data Centre: 1 January 2005 to 30 June 2005 (Michael I. Preston) — BRITISH COLUMBIA ROUND-UP: News of Friends — From the Archives — Final Flight — Publications of Interest (Compiled and edited by Chris Siddle) — Announcements and Meetings.

Volume 2, Number 2, contains: FROM THE EDITOR: A turn of the times —On the covers — FEATURE ARTICLES: Field Survey of Red-eared Sliders (*Trachemys scripta elegans*) in the Lower Fraser Valley, British Columbia, in 2005 (Cory G. Bunnell — Origin and current status of the Pacific Pond Turtle (*Actinemys marmorata*) in British Columbia Francis R. Cook, R. Wayne Campbell and Glenn R. Ryder — Recent range expansion of Sandhill Cranes (*Grus canadensus tabida*) in southeastern British Columbia (Doug -

las Leighton — Diet of Great Horned Owl in the Creston Valley, British Columbia, 1998-2005 (Linda M. Van Damme — NOTES: Anti-predator behaviour by a Mule Deer to Coyotes in Vernon, British Columbia (Chris Siddle) — Attempted capture of a Red-legged Frog by an American Robin (Michael I. Preston) — Evidence of an unusual prey item in a Barred Owl pellet (Christian W. Gronau) — Northernmost nest record of the Flammulated Owl (*Otus flammeolus*) in Canada (Karen L. Wiebe — First nesting record of Say's Phoebe (*Sayornis saya*) in the East Kootenay, British Columbia (Robert S. Ferguson and Mark Dascher) — Current status of the Black-throated Blue Warbler in British Columbia (Gary S. Davidson — Field observations of Gray Flycatchers breeding at Summerland, British Columbia, 1988-2005 (I. Laurie Rockwell) — American Crow predation in an Eared Grebe nesting colony at Rawlings Lake, British Columbia (Chris Siddle) SPECIES OF REGIONAL SIGNIFICANCE: Canvasback Fort St. John (Chris Siddle) — Bobolink — Nakusp to Edgewood (Gary S. Davidson) — WILDLIFE DATA CENTRE: Featured species — Turkey Vulture (R. Wayne Campbell, Michael I. Preston, Linda M. Van Damme, and Diann MacRae — BRITISH COLUMBIA ROUND-UP: Field notes and caring people — News of Friends — From the archives — Final flight — Publications of interest [Compiled and edited by Chris Siddle] — Announcements and meetings.

Annual memberships in the Biodiversity Centre for Wildlife Studies (which included *Wildlife Afield* are $30 (individual), $40 (family), $20 (student), $500 (life). Biodiversity Centre for Wildlife Studies, PO Box 6218, Station C, Victoria, British Columbia V9P 5L5 Canada. Tel/Fax: 250-477-0465; e-mail: editor@wildlifebc.org

Errata *The Canadian Field-Naturalist* 119(3)

Catling, Paul M. 2005 [2006]. Additions to the flora of the continental Northwest Territories from the Great Slave area. Canadian Field-Naturalist 119(3): 437-440.

(page 438) *Actaea rubra* f. *neglecta* : This form had previously been reported by Cody 1961. *Canadian Field-Naturalist* 75(2): 62 from Fort Simpson. Michael Oldham (Ontario Ministry of Natural Resources) reports confirming its presence there in August 2007.

(page 449) *Sonchus arvennsis* subspecies *uliginosus* : Thiert reported this in 1963 *Sida* 1(3): 169 as *S. arvensis*var. *glabrescens* from the Yellowknife Highway (Hwy 3).

My appreciation to Michael Oldham for bringing these to my attention.

PAUL M. CATLING
Agriculture and Agri-Food Canada
Ottawa, Ontario

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

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FRANCIS R. COOK, Editor

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COVER: Elk, *Cervus elaphus*, part of herd near Hartsmore, Ontario. Photographed 1 February 2005 by R. Rosatte. See paper on late born calf – pages 188-191.

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The Canadian Field-Naturalist

Volume 120, Number 2 April–June 2006

A Tribute to George Wayne Douglas 1938 – 2005

JENIFER L. PENNY[1]

[1]Conservation Data Centre, British Columbia Ministry of Environment, Ecosystems Branch, P.O. Box 9993 Stn Prov Govt, Victoria, British Columbia V8W 9R7 Canada.

Penny, Jenifer L. 2006. A tribute to George Wayne Douglas 1938–2005. Canadian Field-Naturalist 120(2): 135–146.

Coming from humble beginnings, George Wayne Douglas, with his determination and strong spirit, established himself as one of British Columbia's most respected botanists. I first met George in 1995 when I began working with him at the British Columbia Conservation Data Centre (CDC). In time, I came to know him as an adept field botanist, a knowledgeable ecologist, an accomplished author, a practical taxonomist, a cunning businessman, a conservationist at heart, and a generous mentor. During our numerous field trips, George often talked about writing his memoirs and enjoyed recounting the stories and adventures that would go into the chapters. He had a lot of different experiences throughout his life that would have resulted in an interesting read. He was a born leader: he had a strong character, held his ground on issues, and had a critical, but practical approach. George had a vision for botany in British Columbia and he brought that vision to fruition.

George (known to family and close friends as Wayne) was born in the Royal Columbian hospital in New Westminster on 22 June 1938. He spent his early years exploring the bushes around the base of Burnaby Mountain near Vancouver, British Columbia, this may have been the root of his inspiration to study botany and ecology later in his life. He grew up in a large family with six brothers and sisters: Bonnie, Marilyn, and David who currently live in British Columbia, and Robert, who lives in South Africa (siblings David Charles and Judy predeceased him). His family was not affluent, so George always aspired to do well for himself, which he certainly accomplished.

As a youth, he excelled at sports but wasn't that interested in academics. In high school (Figure 1), he ran record sprints and was an excellent basketball player, as well as an accomplished golfer. He would continue to enjoy golfing throughout his life, playing at least two to three times a week. When he first started, at about 12 years of age, he used to sneak onto the Vancouver Golf Course, and golf his way to school, hide his clubs and then golf his way home after school. Later he was on the high school golfing team and was an amateur champion. He always knew how to have fun, especially back in high school, but he also worked hard. One of his favourite jobs at that time was at Labatt's Brewery where his Friday afternoons were spent "sampling" the products.

FIGURE 1. George at Como Lake High School (circa 1956).

Despite his lack of interest in scholarly pursuits in high school, George ended up at the University of Washington (College of Forest Resources) in Seattle, Washington, on a track and field, basketball and golf scholarship. George continued to work on his athletics; however, much to his surprise, he became very keen on his studies and excelled in his field. Although he never finished high school, during his educational career he ended up receiving three post-graduate degrees!

George had a scholarship but he still had to work part-time jobs to finance going to university. Amongst his occupations were working in a mill, a cannery and a slaughterhouse. He was also an ambulance and taxi driver. Later in his schooling he got work that better suited his career goals like as a forestry consultant, where he supervised forest inventory, mapping and reforestation projects. He also worked as an ecological consultant while attending University of Washington and completed inventories in the North Cascades National Park focussing not only vegetation, but also wildlife, soils and geology.

During his bachelor studies, George received tutelage from two famous Pacific Northwest botanists, Dr. C. Leo Hitchcock and Dr. Art Kruckeberg. In later years, George dedicated one of his books to Dr. Kruckeberg (*Mountain Plants of the Pacific Northwest*), in which he wrote that Dr. Kruckeberg had inspired him during his first plant identification attempts and started him on the road to his lifelong career in botany. Somehow, George even ended up getting bestowed with Dr. Hitchcock's plant press, a true honour for a botanist! As a result of considerable effort during his bachelor degree, he was accepted into graduate school and studied under Dr. Ronald J. Taylor. George received a Bachelor of Science degree in forestry in 1968 and a Master's of Science degree in 1970 from University of Washington.

George's master's thesis involved a vegetation study in the subalpine zone of the western North Cascades, Washington, which was published in *Arctic and Alpine Research* (Douglas 1970). Following his Master's degree, he moved back to Canada to embark on his Ph.D. at the University of Alberta (Department of Botany) in Edmonton, Alberta, with Dr. Larry Bliss. It was a good time to return to Canada since the United States Army was rallying young troops for Vietnam. His doctorate was a study of alpine and high subalpine plant communities of the North Cascades Range, in Washington and British Columbia, and he published the research in *Ecological Monographs* (Douglas and Bliss 1977). In 1974, following his doctorate at University of Alberta, he received a Postdoctoral Fellowship in the Department of Botany to study lichens of the North Cascade Ranges of Washington (Douglas 1974).

His graduate work took him to the places he loved – the mountains of the Cascade Range. In fact, there is a special place on Mount Baker called Grouse Ridge where he wanted to have his ashes spread, but alternatively he thought that Mount Prevost overlooking his home in Duncan would be a fine place too, which is where his family ultimately scattered his ashes.

After finishing his graduate studies, George took courses in landscape architecture at Pennsylvania State University, which later enhanced his immense enjoyment of gardening at home, but at the time, made him more marketable as a consultant. Then he focussed entirely on developing his consulting firm, Douglas Ecological Consultants Ltd., based out of Victoria, British Columbia. His consulting work was to take him all over British Columbia and to the Yukon Territory and resulted in valuable vegetation interpretations and guidance to land managers on the issues of environmental impacts and biodiversity monitoring.

In 1973 and 1974, he started working in the Yukon Territory, where the alpine was full of new species and breath-taking landscapes. His time there began when he was contracted by the Canadian Wildlife Service to examine the vegetation and soils of Kluane National Park and their vulnerability to land use within the park. George ended up spending eight summers working in the park, a good time for the business, but also some of the best memories of his life.

Parks Canada also hired him to work on many important projects in the 1970s. In fact, he was awarded some of Parks Canada's largest contracts ever. During this time he employed numerous prestigious scientists and colleagues to provide expertise on his projects. Among other projects, he was asked to evaluate the use and ecological impacts of chemical fire retardants in North America and to make recommendations on their future use, to assess the environmental impact of recreational use (mainly human and horse trampling) on different vegetation types in Waterton Lakes National Park, Alberta, and to assess the environmental impact of five potential transportation corridors in Kluane National Park. He also carried out a four-year biophysical inventory project in Kluane National Park, which was a multidisciplinary study that included ten professional scientists and reported on landforms, surficial deposits, soils and vegetation.

Douglas Ecological Consultants also worked on projects involving vegetation reconnaissance of large tracts of land in British Columbia, examining spruce hybridization in the province, evaluating the British Columbia ecological reserve system, air quality monitoring projects using lichens in northern Alberta, and a variety of environmental impact studies.

In the early 1980s, George started working on contracts for the British Columbia Ministry of Environment (MOE), for which he would work until his retirement in 2002. He started out at MOE as a consultant, designing and coordinating a biological monitoring network using lichens in northeastern British Columbia. He also investigated the occurrence of alpine plant communities in British Columbia for the Ecological Reserves unit of MOE, and suggested where new ecological reserves should be established.

FIGURE 2. George (left) and Lloyd Freese above the Tatshenshini River. 1992. Photo credit unknown.

At that time, he also became a Royal British Columbia Museum research associate and started working on a complete taxonomical and ecological treatment of approximately 360 taxa in the Asteraceae (sunflower family) in British Columbia. Unfortunately, only two of the planned three volumes were ever published due to funding difficulties. He was also involved in numerous articles and government documents in the 1980s, and he edited and contributed to an attractive and informative coffee table book on Kluane Park, Yukon, called *Kluane, Pinnacle of the Yukon* (Theberge and Douglas Editors 1980). His work in the Yukon also resulted in the *Rare Vascular Plants of the Yukon* (Douglas et al. 1981).

George also established a strong relationship with ecologists in the British Columbia Ministry of Forests (MOF) in the 1980s as well as the 1990s. He worked on floristic manuals and bibliographies for them, and annotated several thousand sheets of British Columbia plants. George and his colleagues at MOF (Del Meidinger, Andy Mackinnon and Jim Pojar) felt that it was of utmost importance to have a flora for British Columbia to provide a foundation for all inventory, floristic and conservation work going on within the province. Therefore, he collaborated with them on the very first flora for British Columbia and became the chief editor of the *The Vascular Plants of British Columbia* (Douglas et al. 1991-1994). For the first time ever, botanists had a flora for British Columbia all in one work. Previously, botanists had to carry a variable number of floras depending on what part of the province they were working in.

In the 1990s, George was also involved in the following very popular field guides: *Plants of Northern British Columbia* (MacKinnon et al. 1992), *Plants of the Southern Interior of British Columbia* (Parish et al. 1996), and the second, expanded edition of the *Mountain Plants of the Pacific Northwest* (Taylor and Douglas 1995). In total, he contributed approximately 45 publications during that decade that greatly enhanced the knowledge of vascular plants in British Columbia and the Pacific Northwest.

In addition to his valuable contributions to the botanical literature, George also added thousands of valuable collections to major herbaria in Canada. During his career, he collected 13893 specimens, many of which represented new taxa for the province, new range extensions for known taxa, rare or at-risk species, and other interesting finds. From his collections in the Cascade Mountains he and John Packer named a new *Erigeron* (fleabane) for the Pacific Northwest, *Erigeron salishii* (Salish Daisy) (Douglas and Packer 1988). He also made the first collections in British Columbia of species like *Orthocarpus barbatus* (Grand Coulee Owl-clover), *Erigeron leibergii* (Leiberg's Fleabane), and *Tonella tenella* (Small-flowered Tonella).

In 1991, George started working for the British Columbia government as the Program Botanist at the CDC. This position gave him the opportunity to further contribute to floristics in British Columbia through the CDC mission of identifying, tracking, and monitoring the rarest or most at-risk plants in the province. To accomplish this goal, George continued to collect and amass important collections. In addition, through inventory work, George travelled throughout the province chasing the plants that were on the CDC's tracking list and surveying a wide variety of habitats, including range lands, wetlands and mountain tops. The year that I joined the CDC, we toured the peaks of the southern Rocky Mountains for five days via helicopter escort. Because of his background in alpine ecology, mountain excursions were definitely a focus for George, but also critical was our inventory work in the other habitats for rare plants, such as the sand dunes of the west coast of Vancouver Island, the hot springs in the East Kootenays, and the beaches of Osoyoos Lake. These trips sound like a series of holidays but that was where our work took us to confirm the conservation status of rare and at-risk plants in British Columbia.

In order to accurately survey and track the species, George not only saw the need for meticulous inspection of the herbaria collections and for inventory work in poorly surveyed areas as well as in regions under high development pressure, but he also saw the need for an updated flora. Therefore, in the late 1990s he started focusing his efforts on the production of the *Illustrated Flora of British Columbia* (Douglas et al. 1998-2002). At that time, he also co-authored the *Rare Native Vascular Plants of British Columbia* (Douglas et al. 2002) so that land use planners and field workers had an easy-to-use reference to the CDC-listed plants.

The *Illustrated Flora of British Columbia* (Douglas et al. 1998-2002) dominated George's life from the late 1990s to 2002. Since he was so dedicated to its completion, he worked on it at home as much as he did in the office. The production of the flora not only involved coordinating the contributors' schedules, keeping them on timelines and reviewing the products, but it also involved compiling high quality illustrations (some borrowed, others newly commissioned). The maps were a whole other project (published in Volume 8 of the series) – the first complete set of distribution maps for British Columbia plants ever done. It was an enormous effort but with enormous benefits.

The inventory work that George was involved with at the CDC not only allowed for more accurate provincial listing of rare and at-risk taxa, but also allowed him to prepare numerous status reports on the local southeast Vancouver Island and Okanagan Valley Endangered and Threatened plant taxa. As a result of these studies, he authored and co-authored 40 Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports and update status reports, more than any other contributor of reports to the national species assessment team!

Along the way, George encouraged many of the individuals that he mentored to co-author status reports. He often invited enthusiastic students and other protégés to join him on field outings where he was very forthcoming about sharing his botanical knowledge. He also spent time helping the Co-operative Education students that worked at the Royal British Columbia Museum and many others that sought his advice. He encouraged his staff with regular bouts of appreciation. Every year, at Christmas his botanical supporters at the CDC were invited to lunch at his favourite spot, The Royal Colwood golf course clubhouse, where patrons have a great view of the lovely grounds with its ancient Douglas-firs and Garry Oaks, manicured greens and ponds.

Through his work it was obvious that George was a conservationist at heart. He may not have portrayed the image of one in the typical sense, but he always extolled the virtues of preserving natural areas. In the early 1990s, he participated in the Sierra Club expedition down the Tatshenshini River, northern British Columbia, part of a successful campaign to have a protected area established in there (Figure 2).

He became a member of the Garry Oak Ecosystem Recovery Team Rare Plant Recovery Implementation Group, and contributed valuable input to the membership discussions. He was also on the *Adiantum capillus-veneris* (Maidenhair Fern) recovery team and performed an advisory role to the South Okanagan-Similkameen Conservation Program. In his consulting work, he contributed to conservation through research and inventory, but also through work with golf clubs advising them on how to create environmentally friendly courses.

He also supported an important Nature Conservancy of Canada campaign to purchase one of the last remaining sizeable stands of Garry Oak in semi-pristine condition left on southeastern Vancouver Island, a property owned by the Elkington family, located east of Duncan. He did early inventories in the Garry Oak ecosystem, and advised the Nature Conservancy staff about the biodiversity values of the property during the raising of funds to purchase it. In 1999, George had the opportunity to conduct the most intensive and objective study of a Garry Oak woodland ever done in British Columbia on this very property, later coined the "Cowichan Garry Oak Preserve". The study examined the composition, phenology, stand structure, and soils of the Garry Oak woodland. Phenological data was obtained on a weekly basis from March until September and soils were also examined in detail from three soil pits. In 2004, Douglas Ecological Consultants Ltd. repeated the vegetation component of the study to monitor changes after five years (Smith and Douglas 2005).

During his government career, George reached out to many different groups to communicate his message to protect rare and at-risk plants. In particular, he established a relationship with Osoyoos Indian Band, and befriended Environmental Officer Ron Hall. He spent

many summers doing inventories on Osoyoos band lands monitoring the special habitats that they have conserved over the years in the region, while all surrounding properties have been converted to vineyards, orchards, golf courses, and residential and commercial developments. Even after he retired from government in 2002, he continued to work with the band helping them with invasive species control in sensitive rare plant habitats.

When George retired from government after 11 years of service in early 2002, he started up Douglas Ecological Consultants Ltd. full-time once again. He was very excited about getting out in a consulting capacity like the "old days" on some field trips since the inventory work had been scant in recent years with the government. In his capacity as a consultant to government, he became active in a variety of interesting botanical and ecological projects and produced many reports. In the last three years of his life, he worked on numerous status reports, four species at risk recovery strategies, and one multi-species recovery strategy. Sadly, his life and work were cut short by a long battle with cancer. He died on 10 February, 2005 at Cowichan District Hospital, Duncan, British Columbia. He left behind wife Sylvia, son Geordie, daughter-in-law Mary McPhail, and grandchildren Mackenzie and Ryder, his four siblings and numerous nieces and nephews.

He has, however, left a truly inspiring legacy. His botanical contributions are used often by many plant lovers, botanists and ecologists in British Columbia and beyond. He will be remembered as a leader, not a follower, who made things happen. He was hard-working and passionate about his work. His lengthy bibliography and professional experience, which follows, will attest to this assertion.

Other tributes to George W. Douglas appeared in *Botanical Electronic News (BEN)*, the first, an obituary written by his MOF colleagues, Del Meidinger, Jim Pojar and Andy MacKinnon, and the second, a tribute to George's immense bibliography (http://www.ou.edu/cas/botany-micro/ben/ben344.html; http://www.ou.edu/cas/botany-micro/ben/ben351.html). The bibliography found in this article is an updated version of the one that was published in October of 2005 in "*BEN # 351*" and is found at http://www.ou.edu/cas/botany-micro/ben/suppl/351/gwdouglas.html.

An obituary also appeared in the local Duncan and Victoria papers that featured one of George's favourite pictures with his beloved cat, Garfield, where the two of them are reading a Czech satirical, antimilitaristic novel from the First World War given to him many years ago by a valued colleague (Figure 3; http://www.obituariestoday.com/Obituaries/ObitSearchList.cfm).

FIGURE 3. George and his beloved cat, Garfield. Circa 1993. Photo by Sylvia Douglas.

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Positions in Scientific and Professional Societies

Member: Northwest Scientific Association; Ottawa Field-Naturalists' Club; Rare Plant Consortium; Association of Professional Biologists

Research Associate: Royal British Columbia Museum (1991-2004).

Dissertations and Post-doctoral Fellowships

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Postdoctoral Fellowship: 1973-1974, Department of Botany, University of Alberta, Edmonton, Alberta.

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Professional Experience Summary

1966 – 1967: Forester and Consultant with Rayonier, Canada Ltd., Jeune Landing, BC and Mills, and Potter and Mills, Vancouver, British Columbia, where he supervised forest inventory, forest type mapping, and reforestation projects on northern Vancouver Island, British Columbia.

1968 – 1970: Ecological Consultant to the Intercampus Education and Scientific Preserves Committee (Washington Universities) at Western Washington State College, Bellingham, Washington, hired to examine and quantitatively sample more than twenty-five potential natural areas throughout the State of Washington, and recommend which ones should be protected.

1969 – 1974: Ecological Consultant to the United States National Park Service in Sedro Woolley, Washington, where he initially provided a biological inventory (vegetation, wildlife, soils and geology) of the newly formed North Cascades National Park, Washington. He also conducted vegetation analysis of the entire park (18000 km^2) and provided advice and research with respect to vegetation problems.

1973 – 1974: Ecological Consultant to Canadian Wildlife Service, Edmonton, Alberta, and Parks Canada, Winnipeg, Manitoba. Project co-ordinator and chief ecologist examining vegetation and soils of Kluane National Park, Yukon Territory, and their relation to fragility and land use within the park. This study was also co-ordinated with small mammal and bird studies.

1973 – 1974: Ecological Consultant to Canadian Forestry Service, Edmonton, Alberta, reviewing and evaluating the ecological impact and use of chemical fire retardants in North America. He also made recommendations pertaining to the future use of chemical fire retardants in Canada.

1974 – 1975: Ecological Consultant to Canadian Wildlife Service, Edmonton, Alberta, and Parks Canada, Calgary, Alberta. Project co-ordinator and chief plant ecologist for a study designed to assess the environmental impact of recreational use (mainly human and horse trampling) on different vegetation types in Waterton Lakes National Park, Alberta.

1974 – 1975: Ecological Secretariat, Department of Lands and Forests, Victoria, British Columbia. Chief plant ecologist on a three-faceted study in west-central British Columbia. The study included a vegetation reconnaissance of a 1500 square mile area, examination of the spruce hybridization problem in the region, and an evaluation of the ecological reserve system and selection in British Columbia.

1974 – 1975: Ecological Consultant with Don Blood & Associates Ltd., Lantzville, British Columbia, for Parks Canada, Winnipeg, Manitoba. Chief plant ecologist with a biological and geological team assessing the environmental impact of five potential transportation corridors in Kluane National Park, Yukon Territory.

1975 – 1977: Ecological Consultant to Syncrude Canada Ltd., Edmonton, Alberta. This project involved setting up a continuous biological monitoring program for air quality in the tar sands refinery area near Fort McMurray, Alberta. Using lichens as an indicator, the affect of effluents (especially SO_2) and their environmental impacts will be continuously evaluated.

1975 – 2004: Research Associate in Biological Collections, Herbarium, Royal British Columbia Museum, Victoria, British Columbia. Author of a flora on the Asteraceae (Sunflower family) of British Columbia. This work includes a complete taxonomical and ecological treatment of approximately 350 taxa.

1975 – 1979: Ecological Consultant to Parks Canada, Winnipeg, Manitoba. Project co-ordinator and chief plant ecologist on four-year Biophysical Inventory Project in Kluane National Park, Yukon Territory. This multidisciplinary study included landforms, surficial deposits, vegetation, and soils. A total of ten professional scientists were involved in this study.

1977 – 1978: Ecological Consultant to Thurber Consultants Ltd., Victoria, British Columbia, with Department of Public Works Canada, Vancouver, British Columbia. Chief plant ecologist on environmental impact study team. This multidisciplinary study included all aspects from engineering and social to environmental impacts with respect to the paving and relocation of a large section of the Alaska Highway.

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** In the production note, COSEWIC acknowledges the late George W. Douglas and Jacques Labreque for writing the status report.

1978 – 1979: Ecological Consultant to Department of Public Works, Canada – Whitehorse, Yukon Territory. Chief plant ecologist on environmental impact study. Assessed the environmental impact of Alaska Highway relocation and paving between Watson Lake and Haines Junction.

1978 – 1980: Ecological Consultant with Hardy and Associates Ltd. for Department of Public Works, Canada in Whitehorse, Yukon Territory. Chief plant ecologist on revegetation project. This multidisciplinary study examined vegetation and soils and recommended reclamation procedures for a 175 mile segment of the Alaska Highway.

1979 – 1980: Ecological Consultant to British Columbia Ministry of Environment, Land and Parks, Victoria, British Columbia. Designed and coordinated a biological monitoring network (using lichens) in northeastern British Columbia.

1980: Ecological Consultant to Ecological Reserves Unit, British Columbia Ministry of Environment, Victoria, British Columbia. Provided an assessment of alpine plant communities in British Columbia and adjacent regions and their occurrence in existing or proposed ecological reserves.

1981 – 1986: Taxonomical Consultant to British Columbia Ministry of Forests, Victoria, British Columbia. Provided editorial assistance for floristic manuals and prepared several reports, including a floristic bibliography. Identified and annotated several thousand sheets of British Columbia plant material.

1985: Taxonomical Consultant to National Museums of Canada, Ottawa, and World Wildlife Fund. Prepared detailed status reports on four Endangered vascular plants of British Columbia.

1985 – 1986: Interpretive Consultant to British Columbia Provincial Parks, Liard Hotsprings, and Mt. Robson Provincial Parks. Provided interpretive services for Provincial Parks summer interpretive programs.

1986 – 1995: Taxonomical Consultant to British Columbia Ministry of Forests, Victoria, British Columbia. Chief editor and major contributor for the four-volume *Vascular Plants of British Columbia*.

1987: Ecological and Taxonomical Consultant for British Columbia Provincial Parks, Strathcona Provincial Park, with Donald A. Blood & Associates, Nanaimo, British Columbia. Provided ecological and floristic expertise with respect to a preliminary assessment of natural resources.

1988 – 1989: Ecological and Taxonomical Consultant to British Columbia Ministry of Parks, Ecological Reserves Unit, Victoria, British Columbia. Chief co-ordinator for study team (including Blood & Associates and Westland Resources Group) formulating a new ecological reserve system for British Columbia.

1991 – 2002: Program botanist at British Columbia Conservation Data Centre, British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia. Responsible for the tracking and inventorying vascular plants of conservation concern in British Columbia.

1992: Botanist, Sierra Club expedition down the Tatshenshini River, northern British Columbia; part of the campaign to have a protected area established in the region.

2001 – 2004: Recovery team member and scientific advisor, Garry Oak Ecosystem Recovery Team Plants at Risk Recovery Implementation Group.

2002: Recovery team member and scientific advisor, *Adiantum capillus-veneris* Recovery Team.

2002: Ecological Consultant to Parks Canada, Pacific Rim National Park. Chief botanist involved in inventory and invasive species management.

2003: Botanical consultant to British Columbia Ministry of Environment. Chief botanist on inventory projects in South Okanagan Grasslands Protected Area and adjacent parcels.

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Conservation Evaluation of the Prairie Lupine, *Lupinus lepidus* var. *lepidus*, in Canada*

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Douglas, George W., and Michael Ryan. 2006. Conservation evaluation of the Prairie Lupine, *Lupinus lepidus* var. *lepidus*, in Canada. Canadian Field-Naturalist 120(2): 147–152.

In Canada, Prairie Lupine, *Lupinus lepidus* var. *lepidus*, is restricted to southeastern Vancouver Island. Of the nine sites where it has been collected, five are extirpated and the status of two of the populations is uncertain. There are two extant populations; some of the other sites may contain the species in the seed bank. Some of the sites are protected to a certain extent from direct habitat destruction by their remote location, although introduced herbaceous species may pose a serious threat by preventing the establishment of the species at other sites. Fire suppression or the lack of other types of disturbance also likely plays a role in discouraging emergence of *Lupinus lepidus*.

Key Words: Prairie Lupine, *Lupinus lepidus*, endangered, distribution, population size, British Columbia.

The Prairie Lupine, *Lupinus lepidus* Dougl. ex Lindl. var. *lepidus*† is a member of a genus of over 100 species. Most of these occur in North America but the genus occurs on all continents except Australia (Hitchcock et al. 1961). It is one of 20 species of *Lupinus* occurring in British Columbia (Pojar 1999) and of about 27 species in Canada (Scoggan 1978). The genus is of some economic importance in the horticultural trade.

The *Lupinus lepidus* complex has been a source of difficulty to researchers over the years. Hitchcock et al. (1961) state that although the *L. lepidus* complex is distinct, the variation within this group has resulted in a large number of proposed subspecies and varieties of which some are considered to be distinct species by others. According to Phillips (1955), the nomenclature is even more confusing, and the number of synonyms is greater for *L. lepidus* than for any other *Lupinus* species. The work of Detling (1951), Phillips (1955) and Dunn and Gillett (1966) has improved the nomenclature and delineation of *Lupinus* species but many problems remain.

The type specimen of *L. lepidus* var. *lepidus* was collected by David Douglas from "... Fort Vancouver to the Great Falls of the Columbia". Subsequently, Hitchcock et al. (1961) recognized five varieties of *L. lepidus* two of which, var. *lepidus* and var. *lobbii* (A. Gray) C. L. Hitchc., are reported to occur in British Columbia. The latter variety is considered to be a separate species (*L. lyallii* A. Gray) in more recent floras of Canada and British Columbia (eg., Dunn and Gillett 1966; Taylor 1974; Scoggan 1978; Douglas 1990; Pojar 1999) and occurs on well-drained soils in subalpine and alpine areas (Douglas 1990; Douglas and Bliss 1977).

Lupinus lepidus var. *lepidus* as recognized by Hitchcock et al. (1961), Douglas (1990), Douglas et al. (1998a) and Pojar (1999), included *L. minimus* Dougl. in synonomy but they failed to account for the location of the type specimen (Rocky Mountains, Kettle Falls in the upper Columbia River drainage) or the range of *L. minimus* in the western Cordillera east of the Coast-Cascade Mountains. *Lupinus minimus* is considered by other authors to be a separate species (e.g., Cox 1973a, 1973b; Dunn and Gillett 1966; Scoggan 1978; Taylor 1974). Douglas et al. (2002a, 2002b) also now treat *L. minimus* as a distinct entity. The latter has been reported to occur in the Columbia River drainage of southern British Columbia (Dunn and Gillett 1966; Taylor 1974), but no specimens have been located. It is also reported to occur in the Crowsnest area of Alberta (Dunn and Gillett 1966) and, more recently, in and adjacent to Waterton Lakes National Park (Argus and White 1978; Kuijt 1982) and at six locations near the southern Alberta border (Packer 1983). Both Kuijt (1982) and Packer (1983) consider *L. minimus* to be synonymous with *L. lepidus*.

Lupinus lepidus is a multi-stemmed perennial herb 20-45 cm tall (Figure 1; Pojar 1999). The stems are slender with long, soft hairs. The plant has oblanceolate palmate compound leaves that are 5 to 9 foliate and copiously silky-hairy. The leaves are mostly basal with only 1 to 4 leaves on the stem. The petioles are 2-5 times as long as the blade. The racemose, pea-like

*The original field work for the *Lupinus lepidus* project was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002a). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Ryan and Douglas 1996*) and the subsequent assessment of *endangered* (COSEWIC 2000*). This paper includes more recent information that did not appear in the original status report.

†Taxonomy and nomenclature follow Douglas et al. (1998b, 1999, 2001a, b) and Pojar (1999).

blue flowers are similar to those of other Fabaceae species. The petals are 8-13 mm long, and the banner is often lighter or darker and reflexed below the midpoint. The wings are glabrous, the keel ciliate, and the calyx silky-hairy. Both lips are 6-7 mm long, the upper ones of which are bifid for at least half their length. Peduncles are 9-10 cm long, pedicels are 2 mm long and petals are 8-13 mm long. The hairy pods are 1-2 cm long and contain three to five large seeds. In British Columbia, it is separated from three similar looking species by its distinct range in the coastal lowlands on southeastern Vancouver Island. It is distinguished from most other species of *Lupinus* by its small stature, the white appressed hairs covering the stems and leaves and the thick caudex at the base of the plant.

Distribution

Lupinus lepidus extends from southwestern British Columbia to north-western Oregon, west of the Cascade Mountains (Douglas et al. 1990; Pojar 1999). In Canada it is rare on southeastern Vancouver Island, British Columbia (Figure 2; Douglas et al. 2002a; Pojar 1999).

Habitat

Lupinus lepidus inhabits xeric sites ranging from grass-dominated meadows to steep rocky slopes where the vegetation is comprised of scattered clumps of Douglas-fir (*Pseudotsuga menziesii*), Arbutus (*Arbutus menziesii*), and Lodgepole Pine (*Pinus contorta* var. *contorta*). These sites are restricted to southeastern Vancouver Island, where rainfall is low compared to other coastal areas in British Columbia, and during the summer, they often experience an extended period of drought. Associated species include Scotch Broom (*Cytisus scoparius*), Hedgehog Dogtail (*Cynosurus echinatus*), Sweet Vernalgrass (*Anthoxanthum odoratum*), several species of Brome (*Bromus*), and Common Camas (*Camassia quamash*). The habitat at the Somenos site was unnatural, consisting of gravel deposited during railroad or highway construction.

FIGURE 1. Illustration of *Lupinus lepidus*. (Line drawing from Pojar 1999)

TABLE 1. Populations of *Lupinus lepidus* in Canada.

Collection Site	Last Observation	Collector/ Observer	Population data (plants/area in m^2)
Langford Plains (Victoria)	1908	Macoun	Extirpated
Observatory Hill (Victoria)	1915	Newcombe	Extirpated
Koksilah River Valley (Duncan)	1960	Hardy	Unknown
Cattle Point (Victoria)	1973	Brayshaw	Extirpated
Beacon Hill (Victoria)	1993	Brayshaw	Extirpated
Somenos Lake (Duncan)	1994	Douglas	Extirpated
Mount Wells (Victoria) (2 plants/1 m^2 in 2003)	2006	Roemer	No plants
Mount Braden (Victoria)	2005	Roemer	2 plants
Mount McDonald (Victoria)	2005	Roemer	113 plants/75 m^2

Biology

Little is known regarding the biology of *Lupinus lepidus*. However, many species of *Lupinus* share common traits, some of which likely characterize *L. lepidus*. It is likely to be associated with nitrogen-fixing *Rhizobium*, which may allow it to invade sites where soils are low in nitrogen. It is suspected that *L. lepidus* is a short-lived colonizer of recently disturbed sites in xeric, open, exposed areas where it persists for several years. It eventually declines, possibly from competition with more aggressive species that either directly compete for resources or prevent the establishment of seedlings, or from lack of vigour in mature plants. The seeds may not have any dormancy requirements but like other legumes, *L. lepidus* seeds have a hard seed coat which may delay germination for several months or years. Nothing is known regarding pollination, seed set, and survival rates.

Population Attributes

Of the nine Canadian sites from which *Lupinus lepidus* has been collected (Table 1, Figure 2), five populations are extirpated. Another two sites (Koksilah River and Mount Wells) are assumed extant but their status is unknown. Little is known regarding population trends for this species. Monitoring this taxon is difficult because populations may only be comprised of a few plants and therefore, easily overlooked, or they may remain in a seed bank for an unknown period before reappearing. However, four years of data collected at Somenos Lake (extirpated) showed a decline before it was destroyed at the site: 250, 1, 0, and 1 in 1991, 1992, 1993 and 1994, respectively. Other sites with limited data include Mount Wells, which contained nine plants in 2001, only a few plants in 2002, two plants in 2003, and no plants in 2004, 2005 and 2006 (H. Roemer, personal communication). The steady decline at this site is attributed to the re-growth of shrubs following a fire. In addition, in 2005, two plants were observed on Mount Braden (up from single plant in 1996) and 113 plants were observed on Mount McDonald (where they had only previous been known from 1915). In 2006, a single plant was seen on Mount Braden and 54 plants on Mount McDonald, but a thorough search of all the locations from 2005 was not done and therefore, the population should not be considered in decline.

Provincial, National, and Global Ranks

The British Columbia Conservation Data Centre has ranked *Lupinus lepidus* as S1 and placed it on the British Columbia Ministry of Environment Red-list (Douglas et al. 2002a). This is the most critical category for imperiled rare native vascular plants in British Columbia. A rank of S1 is considered "critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals) or because of some factors making it especially vulnerable to extirpation or extinction" (Douglas et al. 2002a). *Lupinus lepidus* is on the Canadian *Species At Risk Act* legal list and the Committee on the Status of Endangered Wildlife in Canada has also assigned this species to the Endangered category (COSEWIC 2000*). Globally, it is ranked G5 or common and secure in its range (NatureServe 2006*).

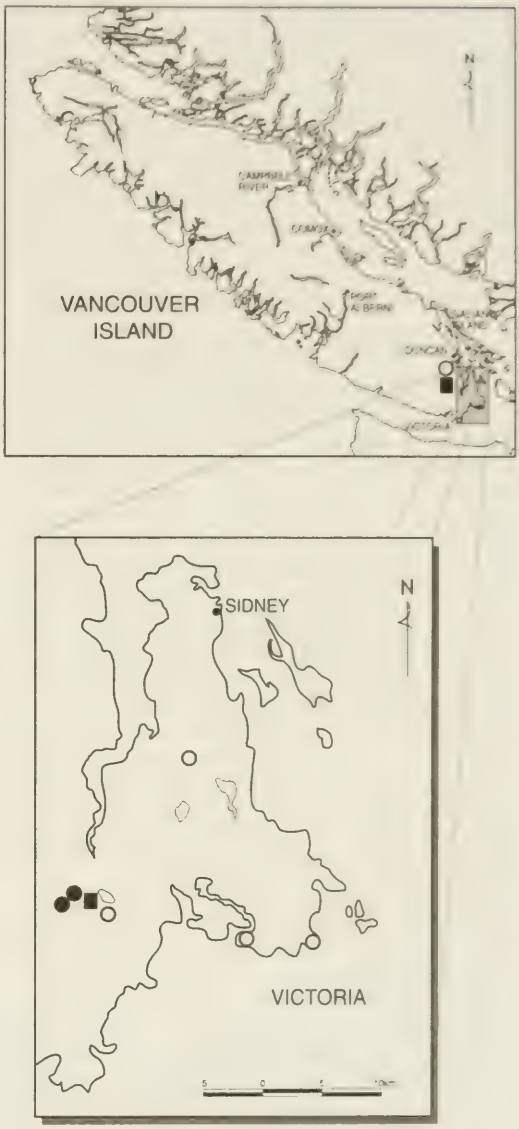

FIGURE 2. The status and location of *Lupinus lepidus* in British Columbia. ● recently confirmed; ■ present status unknown; ○ extirpated

Threats and Protection

The most direct threat to *Lupinus lepidus* is habitat destruction. Grass-dominated meadows, often associ-

ated with Garry Oak-Brome (*Quercus garryana-Bromus*) stands, commonly occurred on gentle slopes on the most climatically favourable coastal areas on south-eastern Vancouver Island and some of the Gulf Islands prior to European colonization. Since colonization both types of vegetation have been subjected to extensive agricultural and residential development. Their destruction has continued to the present, resulting in the elimination of almost all sites occurring outside parks or ecological reserves. The loss of these habitats, estimated at 95% (Lea 2002), severely reduces the availability of sites for the establishment of *L. lepidus* var. *lepidus* and imposes severe limitations on the long-term survival of this species in Canada.

Introduced species including *Cytisus scoparius*, *Cynosurus echinatus* and *Anthoxanthum odoratum* now dominate *L. lepidus* habitats, further threatening the survival of this species. The introduction of aggressive European species has resulted in substantial changes to the grass-dominated meadows associated with *Quercus garryana*, and rocky xeric sites in the Victoria area. *Cytisus scoparius,* in particular, has been one of the most devastating species. It has become a dominant shrub on xeric, exposed sites throughout much of south-eastern Vancouver Island and the Gulf Islands.

Furthermore, the suppression of natural and unnatural periodic fires appears to have resulted in changes to the vegetation of many sites where this species would be expected to occur. In the past, aboriginal peoples may have set fire to these sites to maintain them as an important habitat for wildlife (Roemer 1972). This would have destroyed much of the competing vegetation and created habitats where *L. lepidus* would have had the opportunity to become established. However, since that time, these sites have experienced little disturbance, resulting in invasion and expansion by trees, shrubs, and especially introductions, which effectively eliminate many herbaceous species.

In Canada, some populations of *L. lepidus* are protected to a certain extent by their location on public property. This was not the case, however, for the plant in Beacon Hill Park which was destroyed by maintenance activites along a roadbank in 1994, or for the population on the highway right-of-way at Duncan, which was also destroyed and covered in 1994 by heavy equipment used in a North Cowichan Municipality sewer line project. Extirpation is also a probable fate at Cattle Point and Observatory Hill. Even though Cattle Point is located in a municipal park, it is not protected from trampling by pedestrians and mountain bike enthusiasts. During the summer months, tour buses arrive at this park many times each day resulting in large numbers of people trampling the vegetation along the shoreline and adjacent rock outcrops. As a result of these activities, much of the vegetation has been degraded to the point where the number of potentially suitable habitats for the establishment of *L. lepidus* are far fewer today than in the past. The population could also have been overcome if it occurred in areas now dominated by shrubs.

Observatory Hill is owned by the federal government and is home to the Dominion Astrophysical Observatory. Much of the vegetation has been replaced by exotic species but access is limited to a single road. Although further development on the hill is unlikely to occur, many of the suitable habitats in which *L. lepidus* would likely be found are infested with *Cytisus scoparius*.

Populations at Mount McDonald and Mount Braden are protected by their location within either the Greater Victoria Watershed District (which supplies drinking water to Victoria and adjacent communities and prohibits public access) or the CRD Sooke Hills Wilderness, respectively. Since these areas are dominated by steep rocky terrain and since there are few trails, vegetation has not been degraded to the same extent as it has in more accessible areas near Victoria.

The specific site at which *L. lepidus* was collected in the Koksilah River Valley is not known, thus it is not possible to provide any information on the extent to which this population is protected. However, if it is located on a steep, rocky, xeric sites similar to those found on Mount McDonald, Mount Braden, and Mount Wall, it is unlikely to be threatened in the near future by development or habitat destruction.

The site on Mount Wells is on private land but is not easily accessed at the present time. Nearby mountains, however, have been subject to housing developments in recent years thus the site of *L. lepidus* is not necessarily secure.

Lupinus lepidus is not formally protected in British Columbia, however, it could be in the future since this species is a potential candidate for listing under the provincial *Wildlife Amendment Act* (2004). As part of its commitment to the National Accord (*National Accord for the Protection of Species at Risk*), the province is required to take measures to protect this species. It is on Schedule 1 of the federal *Species At Risk Act* and a recovery strategy (which treats *Lupinus lepidus* in addition to several other species-at-risk) has been proposed (Parks Canada Agency 2005*). The recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. Detailed planning is done at the action plan stage. However, an action plan is not currently available, nor are there any stewardship activities that are currently being implemented.

Evaluation

The Committee on the Status of Endangered Wildlife in Canada and the British Columbia Conservation Data Centre consider *Lupinus lepidus* to be endangered in Canada (Douglas et al. 2002a). It has only been collected nine sites in Canada, only three of which have recently been confirmed, all confined to southeastern Vancouver Island. It is believed to be extirpated at five

of these sites and has not been confirmed recently at two sites. The prognosis for this species is not good considering the threats posed by aggressive competitive species. The loss of suitable habitats at other sites to residential development severely limits the potential of this species to become established at new sites. Furthermore, fire, which may have been an important agent in the continued existence of this species in British Columbia, is now actively suppressed. With so little information known on the ecology of *L. lepidus*, and on its relationship to the environment and other species, successful management of the species is hampered.

Acknowledgments

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Conservation Evaluation of the Seaside Birds-foot Trefoil, *Lotus formosissimus*, in Canada*

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In Canada, Seaside Birds-foot Trefoil, *Lotus formosissimus*, is restricted to the Victoria area on southeastern Vancouver Island and two adjacent islands. Populations at five sites are extant and have been recently inventoried, whereas populations at two or more sites in Victoria are extirpated. Existing populations represent the northern range limits of *L. formosissimus*. Although known populations are protected to a certain extent from direct habitat destruction, introduced herbaceous species may pose a serious threat to the continued existence of most populations and may prevent the establishment of *L. formosissimus* at other sites. Fire suppression, grazing, encroachment and low survivorship are also limiting factors.

Key Words: Seaside Birds-foot Trefoil, *Lotus formosissimus*, endangered, distribution, population size, British Columbia.

Seaside Birds-foot Trefoil, *Lotus formosissimus* Greene, is a member of a genus of about 200 species occurring throughout the world, primarily in temperate zones. It is one of nine species occurring in British Columbia and Canada, four of which have been introduced from the Old World (Pojar 1999; Scoggan 1978).

Lotus formosissimus is a sprawling or ascending, multi-stemmed perennial that grows from a short rootstock and thick taproot to 20-50 cm tall (Figure 1; Pojar 1999). It has compound, pinnate leaves 4-8 cm long with 3 to 7, ovate to obovate leaflets. The three to five yellow and pink pealike flowers are 10-15 mm long and arranged in umbels. The umbels are borne on axillary peduncles 2-6.5 cm long and are usually subtended by trifoliate bracts. The wings of the flowers are pinkish to purplish tinged, the keel is purple tipped, and the banner is yellow and 11-15 mm long. The wings and clawed keel exceed the calyx considerably. Pods are 27-36 mm long by 1.5-2 mm wide and enclose 7 to 15, dark brown to black seeds. *Lotus formosissimus* is distinguished from other *Lotus* species by its perennial habit, membranous stipules, trifoliate bracts (sometimes unifoliate), and pink and yellow flowers (Ryan and Douglas 1994*, 1996*). Bog Bird's-foot Trefoil (*L. pinnatus*) also has yellow but never pink corollas.

FIGURE 1. Illustration of *Lotus formosissimus*. (Line drawing from Pojar 1999).

Distribution

Lotus formosissimus is restricted to the west coast of North America, from southeastern Vancouver Island to central California (Isely 1993; Pojar 1999). In Canada, it is restricted to southeastern Vancouver Island and nearby islands (Figure 2; Dunn and Gillet 1966; Pojar 1999; Douglas et al. 2002a, 2002b).

*The original field work for *Lotus formosissimus* was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002a). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas and Ryan 1996*) and the subsequent assessment of *Endangered*. This paper includes more recent information that did not appear in the original status report.

TABLE 1. Populations of *Lotus formosissimus* in Canada (in Victoria and west of Victoria at Department of National Defense – Rocky Point).

Collection Site	Last Observation	Collector	Population Status (number/area)
Oak Bay, Victoria	1896	Anderson	Extirpated
Foul Bay, Victoria	1912	Henry	Extirpated
William Head, W of Victoria	2002	Fairbarns	19/8 m^2
Bentinck Island, Rocky Point	2004	Fairbarns	278/110 m^2
Rocky Point, E side	2005	Fairbarns	36-53/75.5 m^2
Rocky Point, Church Point	2004	Fairbarns	209-327/137 m^2
Trial Island, Victoria	2004	Fairbarns	383/5000 m^2

Habitat

Lotus formosissimus grows in various coastal meadow and woodland habitats, ranging from open exposed grass-dominated meadows to exposed steep rocky sites inhabited by Garry Oak (*Quercus garryana*), to shaded Garry Oak-Brome (*Quercus garryana-Bromus*) forests. Associated species, which typically occur in the understory of *Quercus garryana* stands, include Lance-leaved Stonecrop (*Sedum spathifolium*), Sea Blush (*Plectritis congesta*), Nodding Onion (*Allium cernuum*), Menzies Larkspur (*Delphinium menziesii*), Orchard Grass (*Dactylis glomerata*), Sweet Vernalgrass (*Anthoxanthum odoratum*), Hairy Cat's-ear (*Hypochaeris radicata*), Common Velvet-grass (*Holcus lanatus*), Early Hairgrass (*Aira praecox*), Ribwort Plantain (*Plantago lanceolata*), and several species of brome (*Bromus*). *Lotus formosissimus* also occurs in vernal seeps. It is suspected that *L. formosissimus* is a poor competitor with a number of perennial grasses because it is absent in a number of grass-dominated micro-sites that are otherwise apparently suitable habitats.

Biology

Little is known regarding the biology of *Lotus formosissimus*. It appears that *L. formosissimus* shoots emerge in spring followed by flowering between May and the end of June when moist soil conditions and warm temperatures are prevalent in *Quercus garryana* stands and meadows. By July, when drought conditions are prevalent, seed maturation and dispersal begin, followed soon thereafter by die-back of the stems to the rootstock, which is located several centimetres below the soil surface. In his demographic studies of *Lotus formosissimus*, M. Fairbarns (personal communication) discovered, based on ex situ experiments, that seeds may remain in the seed bank for at least two years. He postulated that this was a likely explanation for his in situ observations of higher numbers of seedlings than numbers of seeds set in the previous year.

Flowers likely require cross-pollination to set viable seed although pollinators have not yet been identified (Zandstra and Grant 1968). Seeds are believed to be easy to germinate (Hitchcock et al. 1961) but like other members of Fabaceae, they may have a hard seed coat, delaying the germination of seeds for several months or years. Mature plants may be long-lived and recruitment from germinating seeds is likely a rare event.

It is believed that *L. formosissimus*, like other legumes, is associated with nitrogen-fixing *Rhizobium* that provides the plants with an independent source of nitrogen from that in the soil.

Population Attributes

Lotus formosissimus has been collected at seven sites in Canada on southern Vancouver Island or adjacent islands (Table 1, Figure 2). Populations at two of these sites are considered extirpated. Other older collections not listed in Table 1 may or may not represent different locations (e.g., Victoria, and Oak Bay, Victoria). The population on Trial Island has been known since the 1950s and surveyors reported 28 plants in 1994 and 380 plants in 2004. Likewise, the population at Rocky Point has also been observed for over 20 years and was represented by 165 plants in 1993 and 245-380 plants in 2005. The increase, however, is likely attributable to different observers and different sampling methods. It is very unlikely that the populations are actually increasing significantly. The remaining sites have not been monitored for any length of time and thus, no information is available on population trends.

Provincial, National and Global Ranks

The British Columbia Conservation Data Centre has ranked this species as S1 and placed it on the Ministry of Environment Red list. This is the most critical category for imperiled rare native vascular plants in the province. A rank of S1 is considered "critically imperiled because of extreme rarity (five or fewer occurrences or very few remaining individuals) or because of some factors making it especially vulnerable to extirpation or extinction". *Lotus formosissimus* is on the Canadian *Species At Risk Act* legal list (COSEWIC 2000*) and globally, it is G5 or common and secure in its range (NatureServe Explorer 2006*).

Threats and Protection

In the past, the most direct threat to *Lotus formosissimus* was that of habitat destruction. Grass-dominated meadows, often associated with *Quercus garryana-Bromus* stands, commonly occurred on gentle slopes on the southeastern side of Vancouver Island and some of the Gulf Islands prior to European colonization. Since colonization, both types of vegetation have been subjected to extensive agricultural and res-

idential development and have been essentially eliminated outside parks or ecological reserves. Direct habitat destruction, however, is no longer the most important threat. It is the loss of suitable sites outside the current occupied area of *L. formosissimus* that severely limits the potential for this species to spread into new areas and therefore, threatens its long-term survival in Canada.

Less direct factors which threaten known populations include the introduction of aggressive European species. These species have resulted in substantial changes to the grass-dominated meadows associated with *Quercus garryana* and the rocky xeric sites in the Victoria area. One of the most devastating species is Scotch Broom (*Cytisus scoparius*). This species has become a dominant shrub on xeric, exposed sites throughout much of southeastern Vancouver Island and the Gulf Islands and either competes with native plants such as *L. formosissimus* for resources or prevents the establishment of their seedlings.

Furthermore, the suppression of natural and unnatural periodic fires may have resulted in changes to the vegetation of many sites where this species would be expected to occur. In the past, aboriginal peoples probably set fire to many of these sites to maintain them as an important habitat for food plants and wildlife (Roemer 1972). During the past century these sites have experienced little disturbance resulting in increased domination of some sites by trees and shrubs, especially introductions, that effectively eliminate many herbaceous species.

Another limiting factor is grazing. M. Fairbarns (personal communication) observed that grazing prior to seed set had greatly limited seed production and caused reduced vigour among established plants on Bentinck Island.

Finally, demographic constraints also play a role in the viability of populations. Fairbarns (personal communication) found low rates of juvenile survivorship and low levels of seed production. He found that they were related primarily to summer drought and grazing.

All extant populations of *L. formosissimus* in British Columbia are protected from heavy recreational pressure and disturbance caused by the general public. Although these sites contain a large number of introduced species, the latter were not nearly as abundant at Rocky Point, Bentinck Island, and Trial Island as they are at other public sites. It is very likely that restricted public access and lack of disturbance are the primary reasons for the continued existence of *L. formosissimus* at these sites.

The populations at Rocky Point and Bentinck Island are owned by the Department of National Defense. The Department of National Defence is aware of the location of rare species at Rocky Point and there are no plans to develop those areas in which *L. formosissimus* occurs. Bentinck Island is used by DND to detonate unused ammunition, but such activities do not coincide with

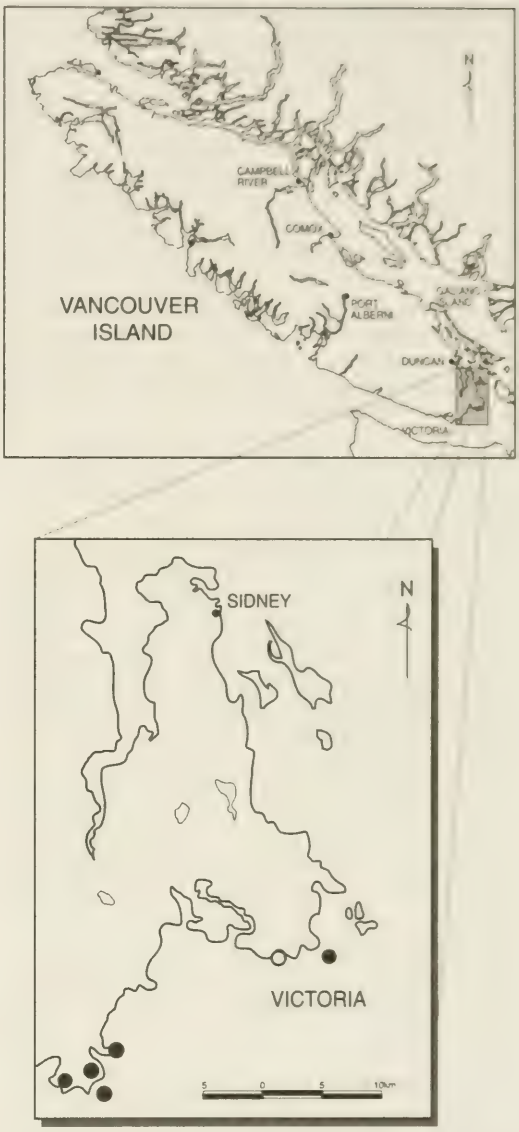

FIGURE 2. The status and location of *Lotus formosissimus* sites in British Columbia. ● – recently confirmed sites, ○ – extirpated site.

locations of *L. formosissimus* on the island. These populations are also protected by the Canadian *Species at Risk Act* by their occurrence on land under federal jurisdiction and therefore, are not likely to be directly harmed. The Canadian Forest Service is also involved in a number of projects with the goal of managing appropriately for species at risk on federal lands, including Scotch Broom removal from sites.

The *Lotus formosissimus* population in Trial Island Ecological Reserve is also provided with a high degree of protection. Despite its proximity to Victoria, it has

very limited public access because it is only accessible by boat, thus preventing excessive disturbance.

A recovery strategy (which treats *Lotus formosissimus* in addition to several other species-at-risk) has been proposed (Parks Canada Agency 2005*). The recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. Detailed planning is done at the action plan stage. In the absence of an action plan, no attempts have been made to introduce *L. formosissimus* to suitable habitats or to increase the number of individuals at current locations. However, Scotch Broom removal at the Bentinck Island site has revealed additional *Lotus* plants (M. Fairbarns, personal communication). The site now offers improved conditions for growth and reproduction.

Evaluation of Status

The British Columbia Conservation Data Centre considers *Lotus formosissimus* to be endangered in Canada (Douglas et al. 2002a). The Committee on the Status of Endangered Wildlife in Canada has also assigned this species to the Endangered category (COSEWIC 2000*). Between 925 and 1060 plants are known from five sites on southeastern Vancouver Island and adjacent islands. The long-term survival of this species in Canada is dubious as a result of a number of limiting factors: shading by aggressive introduced species, poor survivorship, grazing, fire suppression and encroachment. Even though known populations are protected from excessive disturbance on federal lands and in the ecological reserve, the loss of suitable habitats at other sites severely limits the potential of this species to become established at new sites.

Acknowledgments

We thank Matt Fairbarns for population updates for all extant locations and Jenifer L. Penny for assistance in the office.

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Conservation Evaluation of the Bog Bird's-foot Trefoil, *Lotus pinnatus*, in Canada*

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In Canada, Bog Bird's-foot Trefoil, *Lotus pinnatus*, is confined to vernally wet meadows, creek margins, ditches and seepages, where underground water comes to the surface. Seven localities, within a small area on the east coast of Vancouver Island near Nanaimo, British Columbia, have been confirmed in recent years. At two others it is considered extirpated. The lack of protection on private land, alterations to hydrology, and erosion arising from intensive recreational use of primary habitat by off-road vehicles as well as the appearance of invasive, species are the main concerns for British Columbia populations.

Key Words: Bog Bird's-foot Trefoil, *Lotus pinnatus*, endangered species, distribution, conservation, British Columbia.

Bog Bird's-foot Trefoil, *Lotus pinnatus* Hook†, is a low-growing, short-lived perennial of the pea family (Fabaceae) with many erect to spreading stems ranging from 15 to 60 cm long (Figure 1). The pinnately compound leaves are 4-8 cm long, with 5-9 elliptic, oblong or narrowly egg-shaped leaflets. The inflorescence is a compact, stalked, axillary umbel of 3 to 12 flowers. The corollas are 10-15 mm long with a yellow banner and keel and creamy-white wings. The keel petals are fused along one edge that is elongated into a well-defined beak towards the outside of the inflorescence. The calyx is tubular and lobed, with two upper lobes that are joined most of their length. The linear seed pods are 3-6 cm long and 1.5-2 mm wide and contain 5-20 cylindrical, glossy, dark-coloured seeds (Pojar 1999). In the field, several species superficially resemble *L. pinnatus*. Vetches (*Vicia* species) are often present in similar habitats, but the leaves are smaller than those of *L. pinnatus* and the terminal leaflet in *Vicia* spp. is a tendril. Seaside Birds-foot Trefoil (*Lotus formosissimus*) looks similar to *L. pinnatus* except the wing petals of *L. formosissimus* are pinkish-purple, while those of *L. pinnatus* are cream-colored. In addition, though a trifoliate bract usually subtends the flowers of *L. formosissimus*, bracts were sometimes absent in field specimens or only a unifoliate bract was present (Ryan and Douglas 1994*). *Lotus pinnatus* and *L. formosissimus* could be confused if the plants are immature or not in flower, but the two species do not overlap in their distribution in British Columbia. *Lotus formosissimus* is known only from the Victoria area and nearby islands, where it occurs in various xeric habitats, ranging from open grass-dominated meadows to exposed steep rocky sites with Garry Oak (*Quercus garryana*) (Ryan and Douglas 1994*). *Lotus pinnatus* is found only in the Nanaimo area on Vancouver Island, where it occurs in moist soil on exposed, coastal lowland areas. Bird's-foot Trefoil (*Lotus corniculatus*) could also be confused for *L. pinnatus* as it occasionally grows in wet places, but it is usually found in drier, disturbed sites. Also, *L. corniculatus* has completely yellow flowers and its leaflets are smaller and more blunt than the other trefoils.

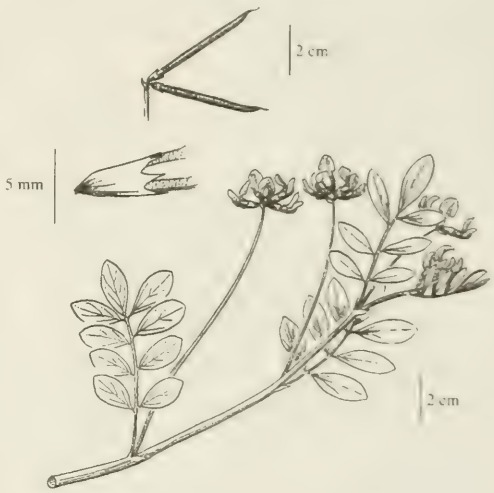

FIGURE 1. Illustration of *Lotus pinnatus* (line drawing in Hitchcock et al. 1961; Pojar 1999).

* The information, gathered during field surveys in 2003 formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Donovan 2004*) and the subsequent assessment of *Endangered* (COSEWIC 2004*). This paper includes more recent information that did not appear in the original status report.

† Taxonomy and nomenclature follow Douglas et al. (1999).

Distribution

Lotus pinnatus occurs in western North America from Vancouver Island, south to northwest Washington, western Oregon and the Columbia River Gorge, to central California and sporadically eastward to Idaho (Figure 2; Isely 1993; Pojar 1999). In Canada, *Lotus pinnatus* is known from seven extant populations within a small area on the east coast of Vancouver Island near Nanaimo (Donovan 2004*).

FIGURE 2. Distribution of *Lotus pinnatus* in North America (from Donovan 2004*).

Habitat

The British Columbia populations of *L. pinnatus* occur within the moist maritime subzone of the Coastal Douglas-fir (CDF) biogeoclimatic zone (Meidinger and Pojar 1991) in the Nanaimo Lowlands Ecosection of the Georgia Depression Ecoprovince (Demarchi 1996*). In this region, the Olympic Mountains in Washington State to the south and the Insular Mountains on Vancouver Island to the west produce a rain shadow effect resulting in a Mediterranean-type climate with warm, dry summers and mild, wet winters. Most of the rainfall occurs during the winter months, and limited precipitation and high temperatures during the summer months result in pronounced summer moisture deficits (Meidinger and Pojar 1991).

Lotus pinnatus grows in open, springy meadows, along the margins of creeks, or in seepages, where underground water comes to the surface and the plants are in close physical contact with cool, flowing water (H. Roemer, personal communication). In all cases, the soils are shallow (< 15 cm), over gently sloping sandstone or conglomerate bedrock with abundant moisture during the growing and blooming period. *Lotus pinnatus* is most commonly associated with Yellow Monkey-flower (*Mimulus guttatus*), Sea Blush (*Plectritis congesta*), White Triteleia (*Triteleia hyacinthina*), Small-leaved Montia (*Montia parvifolia*), Scouler's Popcornflower (*Plagiobothrys scouleri*) and American Speedwell (*Veronica beccabunga* ssp. *americana*). Stands of Douglas-fir (*Pseudotsuga menziesii*) and dense thickets of Nootka Rose (*Rosa nutkana*), Ocean Spray (*Holodiscus discolor*), Nine-bark (*Physocarpus capitatus*) and willow (*Salix* spp.) exist on the margin of some seepages but *Lotus pinnatus* does not occur in the shaded understory of these sites, suggesting that the species is shade-intolerant. Prolonged moisture, edge habitat along streams and meadows and shallow soils derived from sedimentary rock are key habitat components. Other factors, such as slope and aspect are variable and do not appear to be critical in defining suitable habitat. In British Columbia, the elevation for this species ranges between 40 m and 150 m.

Biology

Zandstra and Grant (1968) studied the biosystematics of native and introduced *Lotus* species in Canada and reported that although many of the Old World species are polyploids, none of the North American species examined exhibited the same trait. North American *Lotus* species have a base chromosome number of 6 or 7. Of the species native to Canada, *L. pinnatus* and *L. formosissimus* are considered to be the most closely related, based on morphological, habitat, and cytological characteristics. A chemotaxonomic study using thin-layer chromatography further supported the general relationships among Canadian *Lotus* species with *L. formosissimus* and *L. pinnatus* demonstrating the greatest degree of similarity (Grant and Zandstra 1968). These species differed from other native Canadian species in that both were perennial outcrossers with large flowers on long pedunculate umbels. The other three native species were self-fertile annuals with small flowers. Evolution in angiosperm reproduction has frequently occurred with a decrease in basic chromosome number, a shift from an outcrossing (cross-pollinating) to an inbreeding (self-pollinating) reproductive system and a shift from a perennial to an annual habit (Stebbins 1957). On this basis, Zandstra and Grant (1968) considered *L. pinnatus* and *L. formosissimus* to be more primitive than the annual species.

Lotus pinnatus germinates in the late winter or early spring when soil moisture and temperature conditions are most favourable, and seedling survival appears to be dependent on continuous surface moisture during this period. Though the specific timing of events will depend on local habitat conditions, flowering in *L. pinnatus* generally occurs between May and the end of June.

The pea-like, bisexual flowers are borne at the end of a long peduncle arising from the leaf axil, and the umbellate inflorescences are produced sequentially throughout the growing season. As the flowers senesce, some become progressively more reddish (Isely 1981). During July, when drought conditions are prevalent, seed maturation and dispersal begin, followed by die-back of the stems to the rootstock, which is located several centimetres below the soil surface. The seeds lack any strong adaptations for long-distance dispersal by wind or animal vectors. Most seeds are gravity-dispersed and generally land in the immediate vicinity of the parent plant. The plant's habitat along stream channels may permit the legumes and seeds to be transferred by water during times of seasonal flooding. However, germination and seedling survival appear to depend upon continuous surface moisture, and the species does not appear to be a strong competitor with native shrub species or with invasive alien plants. The chances of a healthy population returning to Canada if local populations become extirpated are highly unlikely. The nearest population in Washington State, from which collections were made in 1940, is 240 km away in Bremerton. Whether this population is extant is unknown.

As with other perennial species in the genus *Lotus*, Zandstra and Grant (1968) suggested that the flowers of *L. pinnatus* required cross-pollination to set viable seed. Given the bright yellow appearance of the flower and the wide keel that serves as a suitable landing platform, flowers of *L. pinnatus* appear to be adapted to bee pollination. Although the importance of the bumblebee to the flower (and vice versa) is yet to be specifically determined, bumblebees were observed visiting flowers of *L. pinnatus* at Harewood Plains during field observations made in 2003. Although bees are capable of dispersing pollen over short distances, cross-pollination between most populations in Canada is unlikely in view of the distances involved.

Like many other legumes, *L. pinnatus* appears to be associated with nitrogen-fixing *Rhizobium* bacteria that occupy root nodules and provide the plants with a source of reduced nitrogen in exchange for a supply of carbon and other nutrients. Specific strains of *Rhizobium* bacteria are required for effective nodulation of *Lotus* species grown as forage crops, such as *L. corniculatus* and *L. tenuis*. To maximize establishment in areas that have never produced *Lotus*, inoculation of seeds with the appropriate rhizobia is necessary (Blumenthal and McGraw 1999).

An examination of root nodules collected from *L. pinnatus* at Harewood Plains indicated the presence of bacteria, most likely of genus *Rhizobium* (S. Berch, personal communication).

Population Attributes

Lotus pinnatus has been reported from nine sites in British Columbia (Figure 3; Table 1), all in the Nanaimo area on Vancouver Island and on nearby Gabriola Island. Of the nine reported records, seven populations were verified in recent years. The remaining two sites have been extensively disturbed and it is unlikely that these populations currently exist. Between 1500 and 2000 individual plants were counted in Canada in 2003 over an area of 650 square metres. Relatively little is known of demographic characteristics and population trends of *L. pinnatus* due to a lack of long-term monitoring. Estimates of population trends in *L. pinnatus* are currently unreliable as the clumped, sprawling habit makes it difficult to identify separate individuals and counting methods have varied with different investigators. Until counting methods are standardized, population numbers should be considered rough estimates.

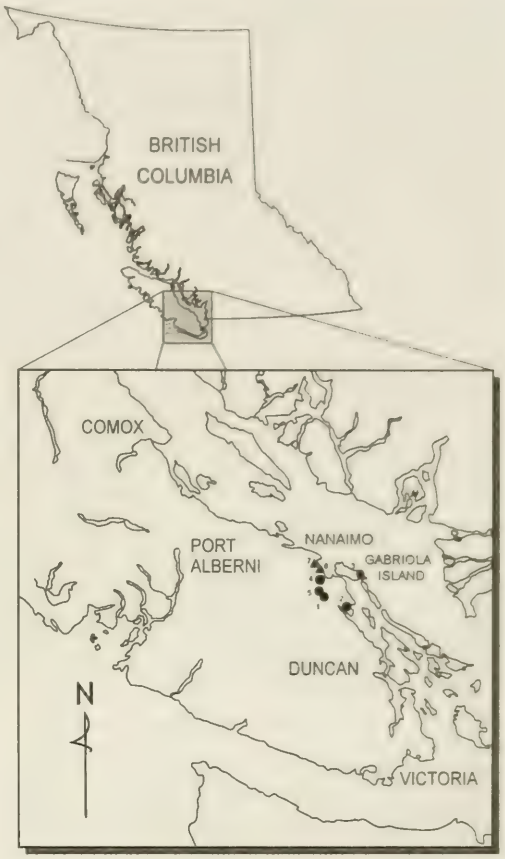

FIGURE 3. Distribution of *Lotus pinnatus* in British Columbia (from Donovan 2004*) ● confirmed; ▲ unconfirmed.

Provincial, National and Global Ranks

The British Columbia Conservation Data Centre has ranked *L. pinnatus* as "S1" and placed it on the "Red list". A rank of "S1" indicates that the species is "critically imperiled because of extreme rarity (often

TABLE 1. Locations and Population Sizes for *Lotus pinnatus* in British Columbia.

Populations	Observation Date	Collector/ Observer	Number of Individual Plants	Apparent Status
Harewood Plains North*	7 July 2003	M. Donovan	1500 in 500 m^2	Extant
Harewood Plains South 1	12 July 2003	M. Donovan	25 in 4 m^2	Extant
Harewood Plains South 2	12 July 2003	M. Donovan	10 in 2 m^2	Extant
Woodley Range	1 June 2003	M. Donovan	120–140 in 90 m^2	Extant
Gabriola Island, off Peterson Road, on Perry Road	25 May 2003	Donovan/Penny	65–70 in 10.5 m^2	Extant
Nanaimo, west of Cinnabar Valley	15 June 2003	M. Donovan	40 in 25 m^2	Extant
Nanaimo, south of Extension	23 June 2003	M. Donovan	30 to 45 in 17 m^2	Extant, but declining
Waddington & Departure Bay Roads Nanaimo	2 June 1939	J.W. Eastham	N/A	Extirpated
Departure Bay Road and Island Highway, Nanaimo	20 June 1965	K. Beamish	N/A	Extirpated

* The collection by W. R. Carter at Mt. Benson in 1 June 1918 is included with this population as Harewood Plains may be considered the foothills of Mt. Benson.

5 or fewer occurrences) or because of factors making it especially vulnerable to extirpation." This is the most critical status that can be applied to a species at the provincial level. Though it currently lacks formal protection in British Columbia, *Lotus pinnatus* is a potential candidate for listing under the provincial *Wildlife Amendment Act* (2004).

At the national level, *Lotus pinnatus* has been assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2004*) and appears on Schedule 1 of the federal *Species At Risk Act* (Environment Canada 2006*).

Globally, *Lotus pinnatus* has a rank of G4G5 which indicates that the plant is apparently secure in most of its range (NatureServe Explorer 2006*).

Threats and Protection

Habitat loss presents a serious and urgent threat to *Lotus pinnatus* in Canada. Over 90% of the extant population of *L. pinnatus* is located on land that is privately owned, making this species vulnerable to habitat loss as a result of urban expansion and residential development.

In addition to potential commercial and residential development, the population of *L. pinnatus* at Harewood Plains is under direct and immediate threat of habitat degradation and fragmentation resulting from intensive, unauthorized use of recreational off-road vehicles; including ATVs, 4 × 4s and dirt bikes (C. Thirkill, personal communication). In some areas at this site, the thin and fragile soils have been rutted down to bedrock and plants have been dislodged on to bare rock where they cannot re-establish (Figure 4). There is high potential for further impacts as vehicles continue to access the site, despite efforts by the former landowner (Weyerhaueser Canada) to block access to off-road vehicles with boulder placements, ditches and the installation of several cement barriers along the access road (C. Thirkill, personal communication). In an effort to minimize the disturbance of sites designated as "Environmentally Sensitive Areas" the City of Nanaimo has established a Development Permit Area on a portion of the property at Harewood Plains (Rob Lawrance, personal communication). As the habitat at Harewood Plains supports several other species at risk such as Dense-spike Evening Primrose (*Epilobium densiflorum*), Green-sheathed Sedge (*Carex feta*), Foothill Sedge (*Carex tumulicola*), Slim-leaf Onion (*Allium amplectens*) and Nuttall's Quillwort (*Isoetes nuttallii*), a working group comprised of representatives from industry, non-governmental organizations and local and provincial governments has been established in order to develop proactive communication with the different land owners, managers and stakeholders at this location.

At the site south of Extension, near Nanaimo, at least some portions of the population have been reported extirpated due to recreational off-road vehicle use and residential development (A. Ceska, personal communication).

Other than habitat destruction, competitive exclusion from native and non-native vegetation represents the most significant ongoing threat to *L. pinnatus* at all sites. Encroachment of native shrub species in potential habitats may prevent this species from occupying new sites. Invasive alien grass species that threaten the persistence of *L. pinnatus* include Sweet Vernalgrass (*Anthoxanthum odoratum*), Orchard Grass (*Dactylis glomerata*), Kentucky Bluegrass (*Poa pratensis*) and Barren Brome (*Bromus sterilis*). Scotch Broom (*Cytisus scoparius*) is the most dominant invasive alien shrub. Logging operations close to (within 50 m of) populations of *L. pinnatus* at Harewood Plains increase the potential for the spread of aggressive native and non-native plant species. By disturbing soils and carrying seeds, off-road vehicles are also a major factor in the spread of invasive non-native plants in sensitive areas.

The population located in the Woodley Range Ecological Reserve is protected, to a certain extent, by its

FIGURE 4. Destruction of habitat caused by all-terrain vehicles at Harewood Plains (Photo George Douglas, 2003).

location within an ecological reserve, but this represents only 7% of the total Canadian population. In addition, plants at this location are vulnerable to adjacent land uses including all-terrain vehicle use, logging and other land clearing activities which could impact on the hydrological features that provide seepage to the location.

A national multi-species strategy that addresses the recovery of *Lotus pinnatus* and five other endangered plant species of vernal pools and other ephemeral wet areas has been completed. This strategy outlines recovery goals for each species, suggests strategic approaches for meeting the recovery goals and recommends that a draft recovery action plan (RAP) be completed by October 2009, which includes proposing Critical Habitat for this species under the *Species At Risk Act* (Parks Canada Agency 2005*).

Evaluation

The British Columbia Conservation Data Centre considers *Lotus pinnatus* to be endangered in British Columbia (Donovan 2004*) and the Committee on the Status of Endangered Wildlife in Canada has assessed the species as Endangered (COSEWIC 2004*). Only a few small fragmented populations remain, and these are restricted to wet meadows of limited occurrence that are considerably disjunct from the main range of the species in the north-western United States. The populations are at risk from continued habitat loss, encroachment of invasive species and recreational off-road vehicle use. Development of the habitat supporting the only sizeable remaining population could result in significant losses to the population (COSEWIC 2004*).

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Conservation Evaluation of the Pacific Population of Dwarf Woolly-heads, *Psilocarphus brevissimus* var. *brevissimus*, in Canada*

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Douglas, George W., Jenifer L. Penny, and Ksenia Barton. 2006. Conservation evaluation of the Pacific Population of Dwarf Woolly-heads, *Psilocarphus brevissimus* var. *brevissimus*, in Canada. Canadian Field-Naturalist 120(2): 163–168.

In Canada, Dwarf Woolly-heads, *Psilocarphus brevissimus* var. *brevissimus*, is restricted to the Similkameen River valley, south of Princeton in southwestern British Columbia and the extreme southeast and southwest corners of Alberta and Saskatchewan, respectively. This paper deals with the three British Columbia populations which represent the northwestern limit of the species which ranges from south-central British Columbia, southward in the western United States to Montana, Idaho, Washington, Oregon, Nevada, Utah, Wyoming , California and Baja California, Mexico. In British Columbia, *P. brevissimus* is associated with calcareous vernal pools and ephemeral pond edges in large forest openings. This habitat is rare in the area the few existing populations could easily be extirpated or degraded through slight changes in groundwater levels, coalbed methane gas drilling, housing development or recreational vehicles.

Key Words: Dwarf Woolly-heads, *Psilocarphus brevissimus* var. *brevissimus*, British Columbia, endangered, distribution, population size.

Dwarf Woolly-heads, *Psilocarphus brevissimus* var. *brevissimus* Nutt.†, is a member of a genus of five species which occur in the Americas (Cronquist 1950). It is one of three species occurring in British Columbia and Canada (Douglas 1998). Two varieties of *P. brevissimus*, var. *brevissimus* and var. *multiflorus*, are recognized. The var. *multiflorus* occurs only in California (Morefield 1993). *Psilocarphus brevissimus* var. *brevissimus* was first recorded in Canada in 1997 (Douglas et al. 1998a).

Psilocarphus brevissimus var. *brevissimus* is a prostrate, matted annual herb with a short taproot (Figure 1; Douglas 1998). The plants are from 8 to 20 cm long. The few leaves are restricted to the stems and are opposite, lance-linear to lance-oblong or lance-triangular, 4-15 mm long and white woolly-hairy. The flower heads are disciform, lack a pappus, and are usually solitary in the leaf axils or at the tips of the branches and lack involucres. The receptacular bracts are 2.4-4 mm long, hooded and balloonlike. The achenes are more or less cylindric, glabrous, nerveless and tipped with a small, 1-2 mm long, offset style.

In British Columbia herbaria, specimens of *P. brevissimus* var. *brevissimus* may be distinguished from *P. elatior* by their prostrate and matted habit and much narrower leaves. It is separated from *P. tenellus* var. *tenellus* by its longer (2.5-4 mm versus 1.3-2.5 mm

FIGURE 1. Illustration of *Psilocarphus brevissimus* var. *brevissimus* (Line drawing by Elizabeth J. Steven in Douglas et al. 1998; 2002a).

* The field work for *Psilocarphus brevissimus* was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas et al. 2003*) and the subsequent assessment of *Endangered* (COSEWIC 2003*). This paper includes more recent information that did not appear in the original status report.

† Taxonomy and nomenclature follows Douglas et al. (1998b; 1998c; 1999; 2001).

TABLE 1. Locations and population sizes for *Psilocarphus brevissimus var. brevissimus* south of Princeton, British Columbia.

Collection site	Observation	Collector/Observer	Number of plants/area
Princeton, Tracey Lake, ca. 0.75 km SE of Lake	1996	Lomer	30/unknown
Princeton, Tracey Lake, ca. 1.3 km ESE of Lake	2002	Douglas and Penny	450/392 m^2
	2004	Douglas and Smith	7200±500/100 m^2
Princeton, Stevenson Lake, ca. 0.75 km SE of	2002	Douglas and Penny	900 000±100 000/570 m^2
	2004	Douglas and Smith	11 775/155 m^2

long) receptacular bracts and its much narrower leaves. For many years in Alberta and Saskatchewan, this species was called *P. elatior* (Packer 1983; Kershaw 2001; Saskatchewan Conservation Data Centre 2004*). In 2004, Alberta taxonomists examined material from both provinces and reidentified them as *Psilocarphus brevissimus* var. *brevissimus* (J. Gould, personal communication). It is quite likely that the "species of concern" ranking given by COSEWIC (2004*) for the Alberta/Sackatchewan populations of *P. elatior* will now be applied to the *P. brevissimus* populations.

North American and Provincial Ranges

Psilocarphus brevissimus var. *brevissimus* ranges from south-central British Columbia, southward in the western United States to Montana, Idaho, Washington, Oregon, Nevada, Utah, Wyoming, California and Baja California, Mexico (Morefield 1993; Cronquist 1994; Douglas 1998). There are also disjunct populations in Chile and Argentina (Cronquist 1950, 1955). In Canada, the species is known only from along 2.6 km of Highway #3 in the Similkameen River valley south of Princeton in south-central British Columbia (Figure 2; Douglas 1998; Douglas et al. 2002) and in the south-eastern and south-western corners of Alberta and Saskatchewan, respectively.

Habitat

Psilocarphus brevissimus var. *brevissimus* occurs in the southern interior of British Columbia in the lower montane zone in the Interior Douglas-fir biogeoclimatic zone (Hope et al. 1991). Climatic conditions are continental, characterized by hot, dry summers, a fairly long growing season and cool winters. A rain-shadow effect prevails in this area due to the presence of the Coast-Cascade Mountains to the west.

Within this zone, the sites occur in a matrix of level to gently sloping Big Sagebrush (*Artemisia tridentata*) shrub/grassland with scattered Ponderosa Pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) [Nomenclature follows Douglas et al. 1998, 1998c, 1999 and 2001]. The area is at the western edge of the distribution of open shrub/grassland at that elevation. Specifically, *P. brevissimus* var. *brevissimus* occurs in calcareous clay soils in vernal pools in large forest openings dominated by Scouler's Popcornflower (*Plagiobothrys scouleri*) and Close-flowered Knotweed (*Polygonum polygaloides* ssp. *confertiflorum* (Figure 3). Associates in these sites include One-spike Oat-grass (*Danthonia unispicata*), Tiny Mousetail (*Myosurus minimus*), Carolina Meadow-foxtail (*Alopecurus carolinianus*), Common knotweed (*Polygonum aviculare*), Lowland Cudweed (*Gnaphalium palustre*), and Annual Hairgrass (*Deschampsia danthonioides*). *Psilocarphus brevissimus* var. *brevissimus* also occurs at the edge of ephemeral ponds in the same type of substratum (Figure 4). The vernal pools and ephemeral pond edges are wet in spring and dry and compacted in the summer.

Psilocarphus brevissimus var. *brevissimus* is considered to be a vernal pool specialist (Schlising and Sanders 1982; Keeley and Zedler 1998; Bauder 2000). Keeley and Zedler (1998) define vernal pools as "precipitation-filled seasonal wetlands inundated during periods when temperature is sufficient for plant growth, followed by a brief waterlogged-terrestrial stage and culminating in extreme desiccating soil conditions of extended duration". The species is able to outcompete grassland species due to its tolerance of inundation, and aquatic/wetland species due to its tolerance of soil dessication and heat during summer drought (Bauder 2000).

Biology

Little information is available on the biology of *Psilocarphus brevissimus* var. *brevissimus* in British Columbia. Only basic facts about its life cycle and reproduction are known.

Keeley and Zedler (1998) recognize four stages in the annual vernal pool cycle: (1) a wetting phase; (2) an aquatic or inundation phase; (3) a waterlogged-terrestrial phase; and (4) the drought phase. In vernal pool species, germination is typically initiated during the wetting or inundation phases. Flowering is usually initiated during the transition to the waterlogged-terrestrial phase. In the Princeton area of south-central British Columbia, this phase occurs during June and fruiting follows in July during the drought period.

Psilocarphus brevissimus var. *brevissimus* is an annual herb that likely reproduces primarily by self-pollination. The assumption of a selfing breeding system is based on the taxon's lack of pollinator attracting structures and the proximity of the stigmas to the central pollen-producing flowers. In addition, the abundance of woolly hairs and lack of achene pappus appear to limit pollen dispersal by wind. Another possibility is that plants set seed without pollination, through asexual reproduction (Cronquist 1950).

Animals may be the primary vectors of seed dispersal for *Psilocarphus brevissimus* var. *brevissimus*. Birds may disperse seeds over small and large geographic areas. The use of vernal pools by various migrating avian species, particularly waterfowl and shorebirds, is well documented in other regions (Silveira 1998). Finally, cottontail rabbits (*Sylvilagus spp.*) are potential agents of dispersal of *P. brevissimus* var. *brevissimus* seeds. A study in California found that *P. brevissimus* var. *brevissimus* seeds were commonly found in cottontail rabbit pellets. The excreted seeds germinated easily, suggesting that the lagomorphs may be important agents of seed dispersal between vernal pools on a small scale (Zedler and Black 1992). British Columbia sites for *P. brevissimus* var. *brevissimus* may provide habitat for Nuttall's Cottontail (*Sylvilagus nuttallii*), a species that frequents grasslands.

Population Attributes

The three populations of *Psilocarphus brevissimus* var. *brevissimus* were discovered in 1997 in the Similkameen River valley, west of Princeton, British Columbia (Table 1; Douglas et al. 1998a). These populations are between approximately 0.8 and 2.6 km apart (Figure 2). During the period from 2002 to 2004, two of the populations decreased in size by about 25%. Plant numbers increased at one site from 450 to about 7200 plants and decreased at the other from about 900 000 to about 12000 plants.

Trends for these populations are not well known but it is obvious that they can be expected to vary markedly due to differences in yearly seed germination and seedling success. Population sizes of this annual herb are strongly tied to annual precipitation patterns (Bauder 2000) and are typical of vernal pool plants (Griggs and Jain 1983).

Provincial, National and Global Ranks

Globally, *Psilocarphus brevissimus* var. *brevissimus* has a rank of G4T4 indicating that in most of its range the plant is secure and frequent to common. Since the species is restricted to British Columbia it has a national rank in Canada of N1. Provincially, *P. brevissimus* var. *brevissimus* has been ranked S1 by the Conservation Data Centre and appears on the British Columbia Ministry of Sustainable Resource Management red list (Douglas et al. 2002). This is the most critical rank that can be applied to species at the provincial level and indicates that the species is "critically imperiled because of extreme rarity (typically five or fewer occurrences or very few remaining individuals) or because of some factor(s) making it especially vulnerable to extirpation or extinction".

Threats and Protection

The major threats to *P. brevissimus* var. *brevissimus* are through drilling for coalbed methane gas, housing development and off-road recreational vehicles. In 2002

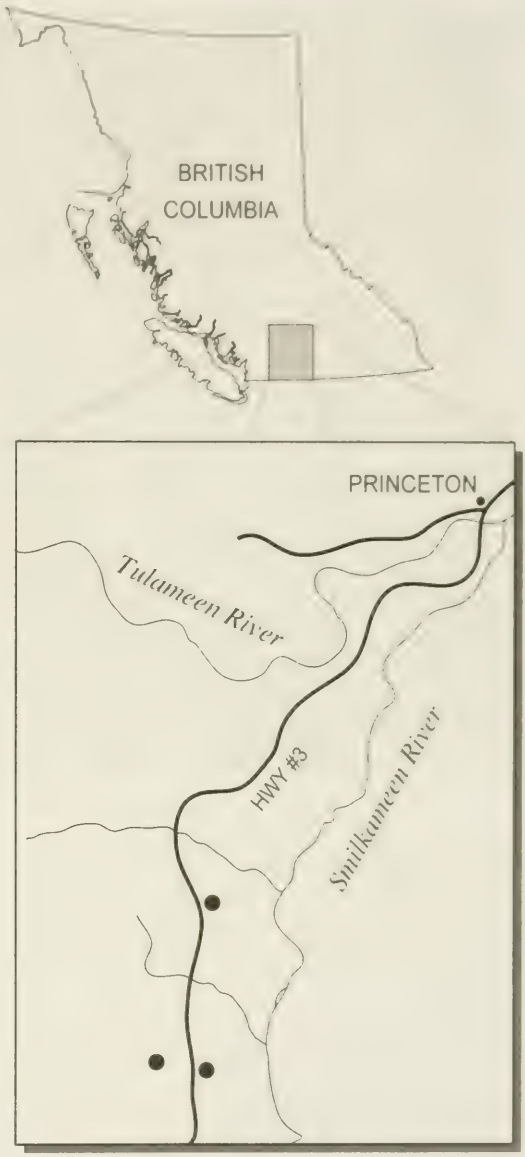

FIGURE 2. Distribution of *Psilocarphus brevissimus* var. *brevissimus* in British Columbia.

three test holes, targeting coalbed methane gas deposits, were drilled in the Similkameen valley. If brought into production the drilling, access roads and pumping stations could cause major degradation in the area.

Other potential threats result from activities that are permitted in the Agricultural Land Reserve. The private property where *P. brevissimus* var. *brevissimus* occurs is on the Agricultural Land Reserve, where primary land use is agriculture. For instance, some types of fill/soil removal are allowable without application to the Agricultural Land Commission (Provincial Agri-

FIGURE 3. Calcareous vernal pool habitat of *Psilocarphus brevissimus* var. *brevissimus* south of Princeton, British Columbia. Colorado Rush (*Juncus confusus*), another rare species in British Columbia, is conspicuous on both sides of the dried-up vernal pool. The several large plants in the habitat are the introduced grass, American Sloughgrass (*Beckmannia syzigachne*).

cultural Land Commission 2003*). On these lands, development pressures do not appear to be an immediate issue at this time. The Agricultural Land Reserve status may prevent subdivision development, but does allow other activities that could also potentially threaten the populations. In recent years many tracts of Agricultural Land Reserve land in southern British Columbia has been converted to housing developments, shopping malls and golf courses, either by decisions of the Agricultural Land Commission or very rarely by an "order in council" by the sitting provincial legislature.

Another threat likely to have a negative impact is recreational off-road vehicle use. The authors observed evidence of all-terrain vehicles and dirt bike use in the area of the sites in 2004. The vernal pools and ephemeral pond edges are wet in spring and are susceptible to permanent changes if disturbed at this.

An additional threat to the population of *P. brevissimus* var. *brevissimus* is its vulnerability to extirpation due to the extremely small occupied area and population size. Such small populations are at risk of inbreeding depression (Primack 1998). Due to lack of genetic variation, these small populations are vulnerable to demographic and environmental variation. Furthermore, suitable habitats for *P. brevissimus* var. *brevissimus* in the southern interior of British Columbia are extremely limited and thus opportunities for colonisation are also limited.

Psilocarphus brevissimus var. *brevissimus* is not formally protected in British Columbia, however, it could be in the future since this species is a potential candidate for listing under the provincial *Wildlife Amendment Act* (2004). As part of its commitment to the National Accord (*National Accord for the Protection of Species at Risk*), the province is required to take measures to protect this species. It is on Schedule 1 of the federal *Species At Risk Act* and a recovery strategy is expected to be completed by the summer of 2006.

Evaluation

The British Columbia Conservation Data Centre considers *P. brevissimus* var. *brevissimus* to be threatened/endangered in British Columbia (Douglas et al. 2002) and the Committee on the Status of Endangered Wildlife in Canada has assessed the species as endangered (COSEWIC 2003*). The three populations are small and vulnerable to a number of threats. With limited knowledge of the plant's biological and ecological requirements, this species is vulnerable to extirpation in British Columbia. Without research on growth requirements and further demographic information, the stability of the present populations will remain unknown. The limited number of plants also reduces the potential for genetic variation, which may be necessary to respond to environmental changes in the future.

Acknowledgments

We thank Frank Lomer for providing information on his original discovery of *Psilocarphus brevissimus* var. *brevissimus* in 1997 and for his assistance in relocating the sites in 2002. Shyanne J. Smith assisted with field work in 2004.

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FIGURE 4. The ephemeral pond habitat of *Psilocarphus brevissimus* var. *brevissimus* south of Princeton. British Columbia. *Myosurus minimus, Plagiobothrys scouleri* and *Polygonum aviculare* are also prominent species on the calcareous clay soils. The adjacent bands of vegetation consist mainly of Meadow Barley (*Hordeum brachyantherum*) in the foreground and Common Cattail (*Typha latifolia*) in the background.

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Conservation Evaluation of Pacific Rhododendron, *Rhododendron macrophyllum*, in Canada*

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In Canada, Pacific Rhododendron (*Rhododendron macrophyllum*) is restricted to the Skagit River drainage and southeastern Vancouver Island in southwestern British Columbia. These populations represent the northern limits of the species, which ranges south to northern California. In British Columbia, *Rhododendron macrophyllum* is usually associated with coniferous forests. Until recently this species was considered to be rare. Results of this study indicate that the populations in the Skagit River watershed are large, extensive and mostly contained in protected areas, thus the species is not considered to be at risk in Canada at this time.

Key Words: Pacific Rhododendron, *Rhododendron macrophyllum*, distribution, conservation evaluation, British Columbia

The Pacific Rhododendron, *Rhododendron macrophyllum* D. Don *ex* G. Don†, is a member of a genus of almost 1000 species occurring mainly in northeastern Asia (Wallace 1993). It is one of three species occurring in British Columbia (Meidinger 1999) and four occurring in Canada (Scoggan 1979).

Rhododendron macrophyllum was first reported by naturalist Archibald Menzies in 1792 in his "Journal of Vancouver's Voyage", and subsequently described by David Don in 1834. Joseph Hooker also described plants collected during Vancouver's voyages, and in 1855 he published a description of this rhododendron under the species name *californicum*. This name was in common use by botanists for close to a century.

Rhododendron macrophyllum is an erect to spreading, branched shrub, 1-8 m tall (Meidinger 1999; Figure 1). The evergreen leaves are alternate, often appearing whorled, ovate or elliptical, 8-20 cm long, 3-6 cm wide, leathery, dark green above, paler beneath and glabrous, or nearly so. The pale-pink to deep rose-purplish corollas are tubular bell-shaped, spotted red-brown and 2.5-4 cm long and up to 5 cm across. The fruits consist of woody capsules 1.5-2 cm long with numerous minute seeds. It is easily separated from the other two *Rhododendron* species in British Columbia. Lapland Rosebay (*Rhododendron lapponicum*) is a northern plant with much shorter habit and smaller leaves, while White-flowered Rhododendron (*R. albiflorum*) is a higher elevation species with white flowers.

North American and Provincial Ranges

Rhododendron macrophyllum is restricted to coastal habitats from northern California north through Oregon and Washington to southwestern British Columbia (Hitchcock et al. 1959). In Canada, it occurs in southwestern British Columbia in the western Cascade Mountains (Skagit River valley) and on southeastern Vancouver Island (Shawnigan and Rhododendron lakes) [Meidinger 1999; Douglas et al. 2002; Figure 2].

Habitat

Skagit River Valley

The *Rhododendron macrophyllum* populations in the Skagit River valley occur on well-drained, coarse-textured, gravelly, dry soils overlain by fibremors. Elevations range from 500 to 870 metres.

About half of the *Rhododendron* populations in the Skagit River valley are within the Interior Douglas-fir (IDF) Zone while the remaining are within the Coastal Western Hemlock (CWH) Zone (Hope et al. 1991; Pojar et al. 1991). Summaries of all plant communities within these zones are taken from Desrosiers and Cadrin (1993*). The four plant communities within the Interior Douglas-fir (IDF) Zone are described below:

(a) Douglas-fir/Falsebox/Feathermoss (*Pseudotsuga menziesii Paxistima myrsinites/Pleurozium schreberi*) community.

Sites for this community are located in the dry, middle part of the Skagit River Valley, on the flats of the

* The field work for the *Rhododendron macrophyllum* project was funded by the British Columbia Conservation Data Centre and The Skagit Environmental Endowment Commission. The results appear in the British Columbia Conservation Data Centre database and a Skagit Environmental Endowment Commission report (Desrosiers and Cadrin 1993*). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Desrosiers and Douglas 1997*) and the current assessment of *not at risk* (COSEWIC 2006*).

† Taxonomy and nomenclature follows Douglas et al. (1998a, 1998b, 1999a, 1999b, 2000, 2001) and Schofield (1992).

FIGURE 1. Illustration of *Rhododendron macrophyllum*. (Line drawing by Lora May Richards)

valley floor. These are the driest IDF sites and were mid-range in terms of their nutrient regime. The 80-115 year old stands are dominated by *Pseudotsuga menziesii, Paxistima myrsinites*, and *Pleurozium schreberi*. Other important species include *Rhododendron macrophyllum,* Lodgepole Pine (*Pinus contorta),* White Hawkweed (*Hieracium albiflorum),* Heart-leaved Twayblade (*Listera cordata)* and Cow-wheat *(Melampyrum lineare* var. *lineare). Rhododendron macrophyllum* had an average cover of 27% in this community.

(b) Douglas-fir – Western Redcedar/Beaked Hazelnut (*Pseudotsuga menziesii-Thuja plicata/Corylus cornuta)* community.

The lowest elevations in the lower part of the valley contained these sites. They tended to be intermediate, both environmentally and floristically, for the IDF in this area. *Pseudotsuga menziesii, Thuja plicata,* and *Corylus cornuta* were dominants in these 80-100 year old stands. Cover values for *Thuja plicata,* Western Hemlock (*Tsuga heterophylla), Paxistima myrsinites*

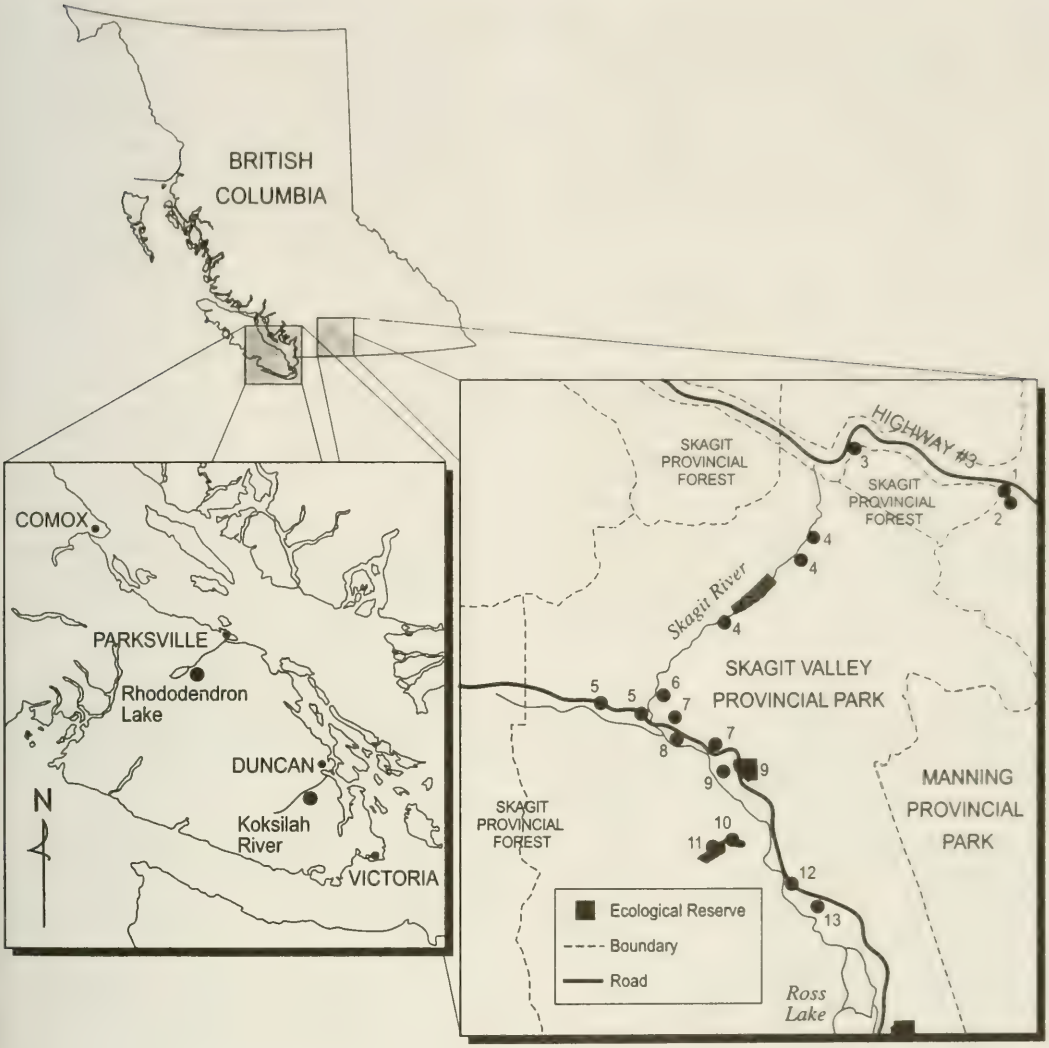

FIGURE 2. The location of *Rhododendron macropyhllum* sites in British Columbia.

and Dull Oregon-grape *(Mahonia nervosa)* were highest in these sites. Average cover of *Rhododendron macrophyllum* was 3%.

(c) Douglas-fir – Western Redcedar/Vine Maple *(Pseudotsuga menziesii-Thuja plicata/Acer circinatum)* community.

This community is found at a higher elevation than other IDF sites, on the east-facing slopes of the Rhododendron Ecological Reserve. The sites were mid-range in term of moisture regime and were nutrient-poor. *Pseudotsuga menziesii, Thuja plicata, Acer circinatum* and Step Moss (*Hylocomium splendens)* were the dominant species. Douglas Maple (*Acer glabrum* var. *douglasii),* Thimbleberry *(Rubus parviflorus* var. *parviflorus),* Oceanspray (*Holodiscus discolor),* Hooker's Fairybells (*Prosartes hookeri* var. *oregana*), Fireweed (*Epilobium angustifolium),* and Lanky Moss *(Rhytidiadelphus loreus)* were also important. *Rhododendron macrophyllum* had an average cover of 3%.

(d) Pacific Rhododendron/Western Tea-berry/Cladonia (*Rhododendron macrophyllum/Gaultheria ovatifolia/Cladonia)* community.

This *Rhododendron* community occurs on the eastern section of the Rhododendron Ecological Reserve as well as on the west side of the Skagit River. These sites were among the driest and most nutrient-poor of all sites sampled. The stands were 105-115 years old.

Tree cover in these plots was extremely low. *Pseudotsuga menziesii* had an average cover of 8% while Western White Pine (*Pinus monticola)* had an average cover of 7%. Average cover of *Rhododendron macrophyllum* was the highest of all plots at 70%. Species of importance in this community included Soopolallie (*Shepherdia Canadensis), Paxistima myrsinites,* Twinflower (*Linnaea borealis), Mahonia nervosa,* Kinnikinnick (*Arctostaphylos uva-ursi)* and species of lichen (*Cladonia* spp.).

All of the plots sampled in the northern half of the study area fell within a single community type in the Coastal Western Hemlock (CWH) Zone. This community may be summarized as follows:

Douglas-fir – Western Hemlock/Falsebox (*Pseudotsuga menziesii-Tsuga heterophylla/Paxistima myrsinites)* community.

Compared to IDF sites the CWH sites have higher moisture regimes, lower nutrient levels and higher tree cover values. In addition to *Pseudotsuga menziesii, Tsuga heterophylla* and *Paxistima myrsinites* other important species include Amabilis Fir (*Abies amabilis),* Grouseberry (*Vaccinium scoparium)* and *Hylocomium splendens*. The stands ranged from 80-150 years old. Average cover of *Rhododendron macrophyllum* was 18%.

Southeastern Vancouver Island

The *Rhododendron* sites on southeastern Vancouver Island are within the Coastal Douglas-fir Zone (Neuzdorfer et al. 1991). The populations east of Shawnigan Lake were found in the following plant community:

Western Redcedar/Pacific Rhododendron-Alaskan Blueberry/Step Moss (*Thuja plicata/Rhododendron macrophyllum-Vaccinium alaskense/Hylocomium splendens)* community.

This community was located on a moderate, southwest slope at an elevation of 490 m approximately 16 km west of Shawnigan Lake. The small (550 m^2) area on which *Rhododendron* occurred was dominated by 40 m tall *Thuja plicata*. The shrub layer was well-developed with *Rhododendron macrophyllum, Vaccinium alaskense,* Red Huckleberry *(V. parvifolium)* and Salal (*Gaultheria shallon)* dominating. A dense layer of mosses and lichens was dominated by *Hylocomium splendens*.

At Rhododendron Lake three markedly different communities occur in bands around Rhododendron Lake. A very wet band of vegetation (about 3-5 m wide), dominated mainly by Sweet Gale (*Myrica gale),* occurs around the immediate edge of the lake. Adjacent to the latter band is another, slightly drier but still very moist 3-10 m band of vegetation containing *Myrica gale* and *Rhododendron macrophyllum*. This saturated habitat is atypical for *Rhododendron macrophyllum*. A wider band (5-25 m wide) of forested vegetation occurs upslope from the lakeside communities. Approximately nine ha was covered by *Rhododendron* plants in the latter two vegetation bands. The two communities containing *Rhododendron* may be summarized as follows:

(a) Pacific Rhododendron – Sweet Gale/Salal (*Rhododendron macrophyllum-Myrica gale/Gaultheria shallon)* community.

This community occurs in a 3-10 m wide band that extends for about 300 m along the south side of the lake. Soils are constantly wet with the presence of Skunk Cabbage (*Lysichitum americanum)* and *Sphagnum* sp. indicating the hydric nature of the site. This site had been logged many years earlier. It appears all trees cut were Yellow-cedar (*Chamaecyparis nootkatensis)* and would have had about a 40-60% average cover. At the present time, *Rhododendron macrophyllum* has an average cover of 47% with only *Gaultheria shallon* being more abundant (average cover of 57%). Bracken Fern (*Pteridium aquilinum),* Labrador Tea (*Ledum groenlandicum)* and *Myrica gale* were also important species in the community.

(b) Western Hemlock/Pacific Rhododendron/Salal (*Tsuga heterophylla/Rhododendron macrophyllum/Gaultheria shallon)* community.

Upslope from the previous community is a forested community dominated by *Tsuga heterophylla*. The site has been partially logged and was previously dominated by *Thuja plicata*. Other coniferous species present, but in low numbers, include *Chamaecyparis nootkatensis, Thuja plicata, Pinus monticola* and *Pseudotsuga menziesii*. Important understory species include *Gaultheria shallon, Rhododendron macrophyllum* and *Hylocomium splendens*. *Rhododendron* has an average cover of 61%.

Biology and Ecology

Research on the biology and ecology of *Rhododendron macrophyllum* has been limited. The majority (60%) of populations in the Skagit Valley showed good to very good vigour. One in three populations had young genets less than one metre in height. These appear, for the most part, to have germinated on rotten logs or thick moss mats. Asexual reproduction, by layering, appears to be much more common than sexual reproduction.

Many sites showed evidence of fire on the dominant trees and charcoal layers were often found in the soil profile. This history of fire and its importance to the maintenance of *Rhododendron macrophyllum* populations was also noted in an Olympic National Forest study (Henderson et al. 1989).

Population Attributes

Approximately 200 populations of *Rhododendron macrophyllum* have been observed at 15 ecosites in the Skagit River valley over a distance of 25 km (Figure 2). Of these, 92 were examined in detail at 13 ecosites for this study (Table 1). Populations ranged in size from 4 m^2 to about 200 000 m^2. The latter area (part of the Rhododendron Ecological Reserve) had an extrapolated count of approximately a million canes. Two populations on Vancouver Island were also examined. Counts at one of them (Rhododendron Lake) revealed 400 plants and approximately 9000 canes.

TABLE 1. Locations and population sizes of *Rhododendron macrophyllum* in south-western British Columbia

Map Location Number(s)/ Ecosite Name	Number of Populations	Approximate Area of Populations (m^2)	Approximate Total Number of Canes
Manning Provincial Park			
1. Cayuse Flats	1	300	1 000
2. Silverdaisy Trail	3	250	1 750
3. Rhododendron Flats	4	150	2 400
Skagit Valley Provincial Park			
4. Upper Skagit Area	3	12	600
5. Klesilkwa River	6	360	600
6. Valley Floor North	2	400	2 100
7. *Pinus contorta* Terrace North	53	3 450	no count
8. *Pinus contorta* Terrace South	4	920	4 000
9. Shawatum Area	4	140	300
10. Rhododendron Ecological Reserve, East	1	200 000	1 000 000
11. Rhododendron Ecological Reserve, West	3	40	550
12. Nepopekum area	6	60	1 000
13. Galene Lakes Trail	3	100	1 250
Vancouver Island			
1. Rhododendron Lake	1	90 000	9 000
2. Shawnigan Lake	1	550	no count

[1] Detailed counts of canes per plant were made for 50 plants at both Cayuse Flats and Rhododendron Lake. Numbers of canes per plant ranged from 18 to 24 at Cayuse Flats and 20 to 25 at Rhododendron Lake (Desrosiers and Douglas 1997*).

The intensive inventory work conducted by the British Columbia Conservation Data Centre resulted in the documentation of thousands of plants in the Skagit Valley (Table 1). Prior to this work the species had been reported as a rare plant in British Columbia (Straley et al 1985; Argus and Prior 1990).

Locations of *Rhododendron macrophyllum* in the nearby Chilliwack River valley were mentioned by Slaney (1971*); however, no references or supporting information were provided in that document. It is possible that these populations could be extirpated due to development. In addition, *Rhododendron macrophyllum* was reported from Lightning Lake in Manning Park (Carl et al. 1952); this population was not verified by the authors or others working in that area.

Provincial, National and Global Ranks

Provincially *R. macrophyllum* is ranked S4 (Douglas et al. 2002) which indicates that it is "rare or uncommon (typically 21 to 100 occurrences); may be susceptible to large-scale disturbances; e.g., may have lost extensive peripheral populations". Since the species is restricted to British Columbia, the National rank is N1. Globally, *Rhododendron macrophyllum* is ranked G5. This ranking indicates that, on a global scale, the plant is considered "frequent to common or very common; demonstrably secure and essentially ineradicable under present conditions".

Threats and Protection

Habitat destruction, due to logging and road building, likely eliminated some populations of *Rhododendron macrophyllum*, especially in the Skagit River area. The establishment of Manning Provincial Park and the more recent Skagit Valley Provincial Park has eliminated most threats to *R. macrophyllum*. On Vancouver Island, where the two populations are located within timber harvesting areas, small informal protected areas have been established.

In the Skagit River valley it was evident that fire had previously swept through most of the ecosites (Desrosiers and Cadrin 1993*). Whenever possible, natural fires are quickly extinguished in the Cascades Mountains. If this control is successful over long periods of time, fuel loads may build up resulting in extremely hazardous conditions. It is, therefore, possible that population sizes may be temporarily reduced from time to time after large burns.

Rhododendron macrophyllum receives protection since all but the Vancouver Island populations occur in provincial parks. The Vancouver Island populations have informal protection set up by the timber companies that own the properties

Until recently there was formal protection under the *Dogwood, Rhododendron and Trillium Protection Act*. This act was repealed in 2002 due to our greater knowledge of the abundance of the species involved and the fact that sufficiently large numbers of their populations occur in protected areas.

Evaluation

Rhododendron macrophyllum was considered rare in Canada for many years (Straley et al. 1985; Argus and Pryor 1990). The present study, however, indicates that the species is not rare and is much more abundant than previously thought. Most of the extant sites

are secure since they are contained either within E. C. Manning Provincial Park, the adjacent Skagit Valley Provincial Park or in several ecological reserves.

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Conservation Evaluation of Slender Collomia, *Collomia tenella*, in Canada*

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In Canada, Slender Collomia, *Collomia tenella*, is restricted to the Princeton area in southwestern British Columbia. The single population represents the northern limits of the species, which ranges from southwestern British Columbia, south in the western United States to Wyoming, Utah, Nevada and Oregon. In British Columbia, *C. tenella* is associated with an eroded section of a steeply sloping, southeast-facing sandy ridge. Population numbers fluctuate and in some years plants fail to appear. The major threats to *C. tenella* are through drilling for coalbed methane gas, sand removal for road construction, housing development and off-road recreational vehicles.

Key Words: Slender Collomia, *Collomia tenella*, endangered, distribution, population size, British Columbia

Slender Collomia, *Collomia tenella* A. Gray† (Polemoniaceae), is member of a genus of about 13 species found in North and South America (Hitchcock et al. 1959). Four species occur in British Columbia and Canada (Scoggan 1979; Pojar 1999). *Collomia tenella* was first recorded in Canada by Douglas et al. (1998a).

Collomia tenella is an ascending to spreading, freely branched, annual, tap-rooted herb up to 15 cm tall (Figure 1; Pojar 1999). The leaves are alternate, linear, entire, 1-5 cm long and 1.5 mm wide. Flowers are single or in pairs at the branch tips, in the leaf axils or at the forks of the branches. The pinkish to white corollas are five-lobed. The calyces, which bow out and often form purplish knobs at the sinuses, have 1-2 mm long, triangular teeth. The fruits consist of capsules with 1-seeded chambers; the seeds become sticky when moistened.

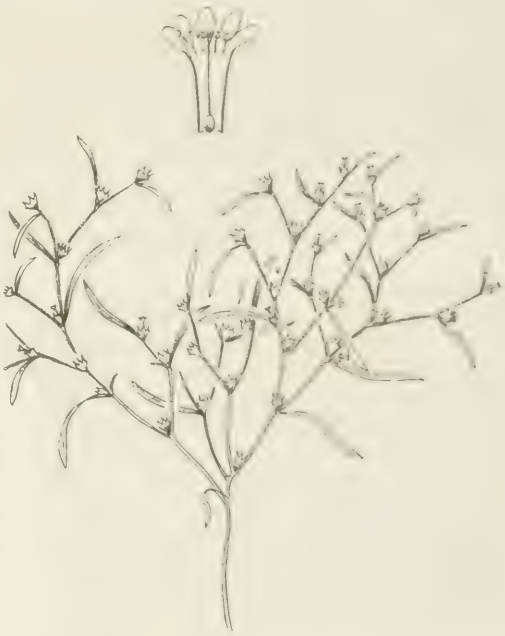

FIGURE 1. Illustration of *Collomia tenella* (line drawing from Douglas et al. 1999b).

North American and Provincial Ranges

Collomia tenella ranges from southwestern British Columbia, south in the western United States to Wyoming, Utah, Nevada and Oregon (Hitchcock et al. 1959). In Canada, *C. tenella* is known only from the Princeton area in British Columbia (Figure 2; Pojar 1999; Douglas 2002a).

Habitat

Collomia tenella occurs in the southwestern interior of British Columbia, along the Similkameen River valley in the Interior Douglas-fir biogeoclimatic zone (Hope et al. 1991). Climatic conditions in this region are continental, characterized by hot, dry summers, a fairly long growing season, and cool winters. A rain-

* The field work for the *Collomia tenella* project was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002a). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas and Penny 2003*) and the subsequent assessment of *Endangered* (COSEWIC 2003*). This paper includes more recent information that did not appear in the original status report.

† Taxonomy and nomenclature follow Douglas et al. (1998b, 1999a, 1999b, 2000, 2001).

shadow effect prevails in this area due to the presence of the Coast-Cascade Mountains to the west.

Within this region, *Collomia tenella* occurs on an eroded, steeply-sloped, southeast-facing section of a sandy ridge (Figure 3). The sandy ridge, formed by fluvial processes during recent glaciation, consists of fine-textured sands. The eroded sections of the slopes are sparsely vegetated with about 20% cover. The vegetation consists of a variety of herbs and shrubs including Arrow-leaved Balsamroot (*Balsamorhiza sagittata*), Timber Milk-vetch (*Astragalus miser*), Narrow-leaved Collomia (*Collomia linearis*), Thread-leaved Phacelia (*Phacelia linearis*), Silky Lupine (*Lupinus sericeus*), Saskatoon (*Amelanchier alnifolia*), Dalmation Toadflax (*Linaria genistifolia* ssp. *dalmatica*), Cheatgrass (*Bromus tectorum*), and Bluebunch Wheatgrass (*Pseudoroegneria spicata*). Scattered Douglas-fir (*Pseudotsuga menziesii*) and Ponderosa Pine (*Pinus ponderosa*) also occur on the ridge (Figure 3).

Biology

There is no information available on the biology and ecology of *Collomia tenella* in the literature. Since it is an annual plant it appears to be absent in some years if environmental conditions for seed germination and/or seedling survival are not favourable. Other annual members of the genus are self-compatible and self-pollinating (Wilken 1993). Seeds may be dispersed by animals since they are sticky when moistened.

Population Attributes

The single population of *Collomia tenella*, covering an area of less than 60 m^2, was discovered in 1997 in the Similkameen River valley, west of Princeton, British Columbia (Figure 2; Douglas et al. 1998a). Counts for the population in 1997, 2000, 2002, 2003 and 2004 were 10, 1, 0, 127 and 0, respectively. In 2003, the area occupied was ca. 56 square metres, with plants in four groups of 56, 67, 1 and 3 plants. These fluctuations indicate that seed germination and/or seedling success of this annual species is highly variable and thus, trends are difficult to determine. A fairly thorough search in adjacent areas in southern British Columbia have not revealed similar habitats or other populations of this species.

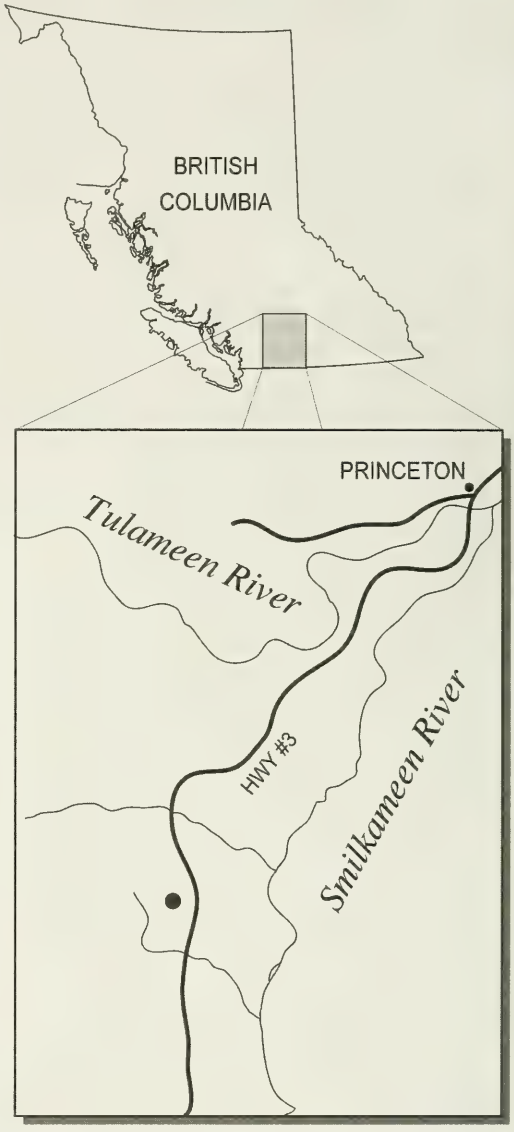

FIGURE 2. Distribution of *Collomia tenella* in British Columbia.

Provincial, National and Global Ranks

The British Columbia Conservation Data Centre has ranked *Collomia tenella* as S1 and placed it on the British Columbia Ministry of Environment Red list (Douglas et al. 2002a). This is the most critical category for imperilled rare native vascular plants in British Columbia. A rank of S1 is considered "critically imperilled because of extreme rarity (5 or fewer occurrences or very few remaining individuals) or because of some factors making it especially vulnerable to extirpation or extinction" (Douglas et al. 2002a). Since the species is restricted in Canada to British Columbia, the National rank is N1. Globally, *C. tenella* is ranked "G4?" or apparently secure but with a range of uncertainty which includes the possibility it is more vulnerable or conversely that is more widespread, abundant, and secure.

Threats and Protection

The major threats to *Collomia tenella* are through drilling for coalbed methane gas, sand removal for road construction, housing development and off-road recreational vehicles. In 2002, three test holes targeting coalbed methane gas deposits were drilled in the Simil-

FIGURE 3. *Collomia tenella* habitat occurs on the eroded section near the top of this sandy ridge south of Princeton, British Columbia. Prominent trees on the ridge are *Pseudotsuga menziesii* and *Pinus ponderosa*.

kameen area. If brought into production, the drilling, access roads and pumping stations could cause extensive degradation to the natural habitat in the area.

Other potential threats result from activities that are permitted in the Agriculture Land Reserve. The private property where *C. tenella* occurs is in the Agricultural Land Reserve, where primary land use is agriculture. For instance, some types of fill/soil removal are allowable without application to the Agricultural Land Commission (Provincial Agricultural Land Commission 2003*). On these lands, development pressures may not appear to be an issue at this time. The Agricultural Land Reserve status may prevent subdivision development, but does allow other activities that could also potentially threaten the populations. In recent years many tracts of Agricultural Land Reserve land in southern British Columbia has been converted to housing developments, shopping malls and golf courses, either by decisions of the Agricultural Land Commission or very rarely by an 'order in council' by the sitting provincial legislature.

Another threat likely to have a negative impact is recreational off-road vehicle use. The authors observed evidence of all-terrain vehicles and dirt bike use in the area of the sites in 2002. The steep and relatively unstable slopes where *C. tenella* occurs are highly susceptible to disturbance but at the same time, present a desirable challenge for off-roaders.

Although weeds are not a major threat to *C. tenella* populations, weed control activities do constitute a minor potential threat to populations. Under the *Weed Control Act*, an occupier must control noxious weeds growing or located on land and premises. Marginally specific chemical weed control compounds that kill broad-leaved plant species would likely also kill *C. tenella*. Noxious weeds such as Dalmation Toadflax (*Linaria genistifolia* var. *dalmatica*) and Cheatgrass (*Bromus tectorum*) occur in the *C. tenella* habitat and could increase. Currently the habitat is not highly invaded, but a variety of other introductions could also eventually take root there as they have in adjacent habitats in the surrounding landscape. Therefore, the ecological integrity of the *C. tenella* habitat could eventually become as comprised as some of these other surrounding habitats are.

An additional threat to the population of *C. tenella* is its vulnerability to extirpation due to the extremely small occupied area and population size. Such small populations are at risk of inbreeding depression (Primack 1998). Due to lack of genetic variation, these small populations are vulnerable to demographic and environmental variation. Furthermore, suitable habitats for *C. tenella* in the southern interior of British Columbia are extremely limited and thus, opportunities for colonisation are also limited.

Collomia tenella is on Schedule 1 of the federal *Species at Risk Act*. As part of its commitment to the National Accord (*National Accord for the Protection of Species at Risk*), the province is required to take measures to protect this species. A recovery strategy will be required under this commitment. Additionally, *C. tenella* is a potential candidate for listing under the provincial *Wildlife Amendment Act*.

Evaluation

The British Columbia Conservation Data Centre considers *Collomia tenella* to be Endangered in British Columbia (Douglas et al. 2002a) and the Committee on the Status of Endangered Wildlife in Canada has also assessed the species as Endangered (COSEWIC 2003*; Douglas 2005*). The single population is small and vulnerable to a number of threats. The small number of plants also reduces the potential for genetic variation which may be necessary to respond to environmental changes in the future. Without research on growth requirements and more demographic information, the stability of the present populations will remain unknown, but the population appears to be quite vulnerable.

Acknowledgments

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Conservation Evaluation of the Small-flowered Tonella, *Tonella tenella*, in Canada*

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In Canada, the Small-flowered Tonella, *Tonella tenella*, is restricted to the west side of Saltspring Island in the Gulf Islands of southwestern British Columbia. This population represents the northern limits of the species which is disjunct from its main range in southern Washington (Columbia River gorge), through Oregon to central California. In British Columbia, *Tonella tenella* is associated with rock outcrops and dry, steep, sparsely forested talus slopes at elevations of 50 to 300 m. The population on Saltspring Island is on private property and not directly imperilled at this time. There is, however, a potential for housing development in the future on this waterfront site, thus the authors consider the species endangered.

Key Words: Small-flowered Tonella, *Tonella tenella*, endangered, distribution, population size, British Columbia.

The Small-flowered Tonella, *Tonella tenella* (Benth.) Heller†, is a member of a genus of only two species occurring in western North America (Hitchcock et al. 1959). It is the only species found in British Columbia and Canada (Pojar 2000). *Tonella tenella* was first recorded in Canada by Douglas and Ruyle-Douglas (1978).

Tonella tenella is a slender, ascending to prostrate, annual herb from a delicate taproot (Figure 1; Pojar 2000). The smooth, often branched stems are 5-25 cm long with opposite leaves 1-2 cm long. The leaves are stalked, simple, ovate to round, and few-toothed or lobed below and unstalked and deeply 2-3 lobed above. The blue or white flowers are small, slightly zygomorphic and long-stalked with deeply five-lobed calyces. The corollas are also five-lobed. There are four, epipetalous stamens and one pistil with 2 ovules. Anthers are 0.4 mm long. The fruits are obtuse to globe-shaped capsules containing 2 to 4, 1-1.5 cm long, wingless seeds.

Distribution

The southwestern British Columbia occurrence of *Tonella tenella* is disjunct from its main range in southern Washington (Columbia River gorge), through Oregon to central California (Wetherwax 1993; Pojar 2000). In Canada, *T. tenella* is known only from the west side of Saltspring Island in the Gulf Islands of southwestern British Columbia (Figure 2; Pojar 2000; Douglas et al. 2002a, 2002b).

FIGURE 1. Illustration of *Tonella tenella* (Line drawing from Douglas et al. 2000)

* The field work for *Tonella tenella* was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002a). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas and Penny 2003*) and the subsequent assessment of *Endangered* (COSEWIC 2003*). This paper includes more recent information that did not appear in the original status report.

† Taxonomy and nomenclature follows Douglas et al. (1998a, 1998b, 1999a, 1999b, 2000, 2001) and Schofield (1992).

TABLE 1. Locations and sizes of *Tonella tenella* subpopulations on Saltspring Island, British Columbia.

Collection site	Last Observation	Collector	Number of plants/area (m^2)
1- Upper slope, south	1976	Douglas	unknown
2- Upper slope, north	2002	Lomer	56+ /40.18
3- Mid-slope	2002	Lomer	100-150/15
4-Lower slope	2002	Douglas	65+/-15/6
5- ca. 10 m uphill from beach	2002	Lomer	30 /1

Habitat

Tonella tenella sites in British Columbia are found in a climatic and floristic anomaly in coastal British Columbia, the dry Coastal Douglas-fir (*Pseudotsuga menziesii*) Zone (Nuszdorfer et al. 1991) of southeastern Vancouver Island. This area is in a rainshadow belt created by the Olympic Mountains to the south, resulting in a relatively warm and dry Mediterranean climate.

Within this region, *Tonella tenella* occurs on west-facing slopes on stable talus. This talus occurs in open Big-leaf Maple (*Acer macrophyllum*)-Arbutus (*Arbutus menziesii)* forests, where associates include Cleavers (*Galium aparine*), Little Western Bitter-cress (*Cardamine oligosperma*), Miner's-lettuce (*Claytonia perfoliata*), Common Vetch (*Vicia sativa*), Barren Brome (*Bromus sterilis*), and Large-flowered Blue-eyed Mary (*Collinsia grandiflora*) or in open Douglas-fir – Arbutus – Garry Oak forests with Oregon Beaked Moss (*Kindbergia oregana*), heron's-bill moss (*Dicranum* species), Harford's Melic (*Melica harfordii*), *Galium aparine*, Upright Hedge-parsley (*Torilis japonica*) and Barren Brome (*Bromus sterilis*).

Biology

Species of *Tonella*, along with its sister genus, Blue-eyed Mary (*Collinsia*) of the tribe Collinsieae, are self-compatible annuals (Armbruster et al. 2002). *Tonella tenella* is considered a small-flowered type and according to Armbruster et al. (2002), large- and small-flowered taxa appear to have differences in timing of self-pollination. Large-flowered taxa maintain herkogamy (spatial separation of anthers and stigmas) early in anthesis by differential elongation of staminal filaments, while small-flowered taxa do not show this elongation pattern. As a result, large-flowered taxa experience a delay in self-pollination whereas in small-flowered taxa, anther-stigma contact and self-pollination occur early. Furthermore, the stigmas are receptive to pollen-tube growth early in *Tonella* species. Small-flowered populations are almost certainly autogamous (Armbruster et al. 2002). Low elevation pollinators for the tribe include the insects *Bombus, Anthophora, Emphoropsis, Synhalonia* and *Osmia* (Armbruster et al. 2002).

Population Attributes

Four small subpopulations of *Tonella tenella* were recently confirmed in 2002 at the Saltspring Island site. These subpopulations, plus an earlier (1976) collection record, occur in a narrow band extending up the mountainside for about 425 m. The subpopulations consisted of 6 to 356 plants with areas of 1 to about 40 m^2 (Table 1). Since the plant is inconspicuous and extremely difficult to detect, it is quite likely other subpopulations occur on the slope.

Provincial, National and Global Ranks

Globally, *Tonella tenella* has a rank of G5 indicating that in most of its range the plant is common. Since the species is restricted to British Columbia it has a national rank of N1. Provincially, *T. tenella* has been ranked as S1 by the Conservation Data Centre and appears on the British Columbia Ministry of Environment Red List (Douglas et al. 2002a). This is the most critical rank that can be applied to species at the provincial level and indicates that the species is "critically imperiled because of extreme rarity (typically five or fewer occurrences or very few remaining individuals) or because of some factor(s) making it especially vulnerable to extirpation or extinction".

Threats and Protection

The most immediate threat to *Tonella tenella* in British Columbia is habitat destruction through a housing development on waterfront private property. Suppression of both natural and human-induced fires in the last century may also have had an effect on the survival of *T. tenella*. The vegetation in this region would naturally be maintained by fires; however, in their absence, high fuel loads build and catastrophic fires could result. This may result in unsuitable conditions for *T. tenella*. Introduced species are also a problem. The vegetation characterizing the *T. tenella* site has been altered by the introduction of European species. Although a large number of native forbs occur in these areas, much of the vegetation is dominated to a large extent by introduced species, particularly grasses, including a number of species of *Bromus*. The *Tonella tenella* site occurs on private land.

Tonella tenella is not formally protected in British Columbia; however, it could be in the future since this species is a potential candidate for listing under the provincial *Wildlife Amendment Act* (2004). As part of its commitment to the National Accord (*National Accord for the Protection of Species at Risk*), the province is required to take measures to protect this species. It is on Schedule 1 of the federal *Species At Risk Act* and a recovery strategy will be required.

Evaluation of Status

The British Columbia Conservation Data Centre considers *T. tonella* to be Endangered in British Columbia (Douglas et al. 2002a). The Committee on the Status of Endangered Wildlife in Canada has also assigned this species to the Endangered category (COSEWIC 2003*). Only one extant population of *Tonella tenella* is known in British Columbia; thus, the loss of the one site would result in the loss of the species from British Columbia and Canada. Potential housing developments threaten *T. tenella* in Canada since the one site occurs on private oceanside property.

Acknowledgments

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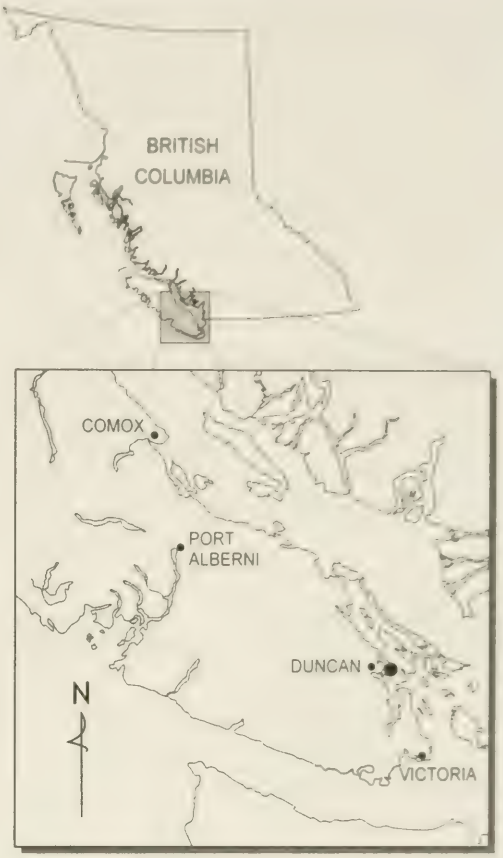

FIGURE 2. Distribution of *Tonella tenella* in British Columbia.

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Conservation Evaluation of Stoloniferous Pussytoes, *Antennaria flagellaris*, in Canada*

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Douglas, George W., Jenifer L. Penny, and Ksenia Barton. 2006. Conservation evaluation of Stoloniferous Pussytoes, *Antennaria flagellaris*, in Canada. Canadian Field-Naturalist 120(2): 183–187.

In Canada, Stoloniferous Pussytoes, *Antennaria flagellaris*, is restricted to the Similkameen River valley south of Princeton, in south-western British Columbia. The three populations represent the northern limits of the species which ranges from south-western British Columbia, south in the western United States to Idaho, Wyoming, Nevada and California. In British Columbia, *Antennaria flagellaris* is associated with eroded, unstable, calcareous clay seepage slopes on open, southerly aspects. This habitat is infrequent in the Similkameen River area and the few existing plant populations could easily be extirpated through slight changes in drainage through drilling for coalbed methane gas, road-building, or housing development.

Key Words: Stoloniferous Pussytoes, *Antennaria flagellaris*, endangered, distribution, population size, British Columbia.

Stoloniferous Pussytoes, *Antennaria flagellaris* (A. Gray) A. Gray† is a member of a genus of approximately 35 species mainly of North America but also found in South America (Cronquist 1994). Fifteen species occur in British Columbia (Douglas 1998) and approximately 18 in Canada (Kartesz 1999). *Antennaria flagellaris* was first recorded in Canada by Douglas et al. (1998a).

Antennaria flagellaris is a stoloniferous, short-lived perennial from a fibrous root (Figure 1; Douglas 1998). The stolons are up to 10 cm long while the few central flowering stems are up to 3.5 cm tall. The numerous basal leaves and the few stem leaves are linear to linear-oblanceolate, silky woolly-hairy and 1-3 cm long. The flower heads are terminal with involucres of two types. The female involucres are 7-13 mm tall bracts that are tinged brown or reddish-brown, thinly woolly-hairy below. The male involucres are 4-7 mm tall translucent bracts that are brownish at the tips. The female flowers are 5-7 mm tall while the male flowers are 3-4.5 mm tall. The single-seeded achenes are elliptic, warty and 2-3 mm long with a 6-8 mm tall pappus that has white, hairlike bristles.

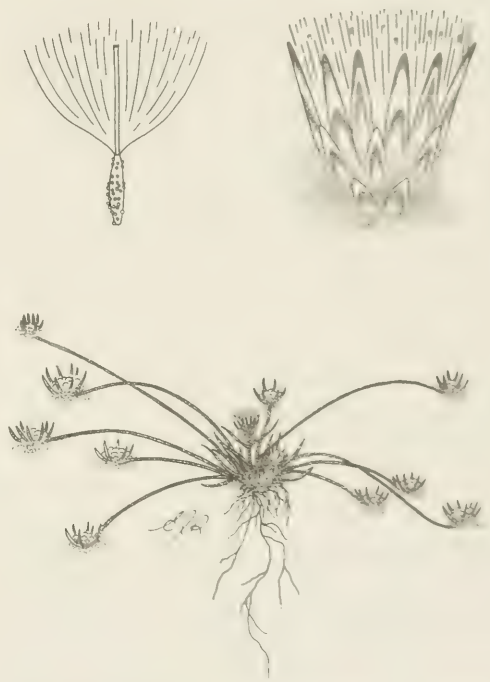

FIGURE 1. Illustration of *Antennaria flagellaris* (Line drawing by Elizabeth J. Steven in Douglas et al. 1998, 2002b).

Distribution

Antennaria flagellaris ranges from southwestern British Columbia, south in the western United States to Idaho, Wyoming, Nevada and California (Cronquist

* The field work for *Antennaria flagellaris* was funded by the British Columbia Conservation Data Centre. The results appear in the British Columbia Conservation Data Centre database and a rare plant manual (Douglas et al. 2002a). This information formed the basis for a Committee on the Status of Endangered Wildlife in Canada status report (Douglas and Penny 2004*) and the subsequent assessment of *Endangered* (COSEWIC 2004*). This paper includes more recent information that did not appear in the original status report.

† Taxonomy and nomenclature follow Douglas et al. (1998b, 1999, 2001).

TABLE 1. Locations and Population Sizes for *Antennaria flagellaris* near Princeton, British Columbia.

Collection site	Last Observation	Collector	Number of plants/area (m^2)
1. Stevenson Creek	1997	Lomer	50 ± 3 or 4
2. Whipsaw Creek, 2 km N of	1997	Lomer	Unknown
3. Stevenson Lake, 300 m NE of	2002	Douglas and Penny	1 400 000 ± 100 000/ 2100
4. Tracey Lake	2003	Lomer	4-500/84

1994). In Canada, *A. flagellaris* is known only from along a 3.2-km length of Highway #3 in the Similkameen River valley south of Princeton in southwestern British Columbia (Figure 2; Douglas 1998; Douglas et al. 1998a, 2002a, b).

Habitat

Antennaria flagellaris occurs in the southern interior of British Columbia along the Similkameen River valley in the lower montane zone in the Interior Douglas-fir biogeoclimatic zone (Hope et al. 1991). Climatic conditions in this region are continental, characterized by hot, dry summers, a fairly long growing season, and cool winters. A rainshadow effect prevails in this area due to the presence of the Coast-Cascade Mountains to the west. Within this zone, *A. flagellaris* occurs in calcareous, gravelly-clay soils or gravelly sands. The sites are characterized by a unique hydrology. The slopes, which are moderate (20-30%) with open southerly aspects, are eroded, unstable, and characterized by ephemeral seepage. These moist microsites are saturated by underground water in the winter and dry up in the summer. The slow down-slope movement that occurs as a result of the unusual hydrology is unique in the region and excludes many taxa which are not able to tolerate the conditions. As a result, the slope is disturbed and sparsely vegetated with *A. flagellaris* being the dominant component (Figure 3).

Vegetation in the vicinity of the *A. flagellaris* sites is characterized by Big Sagebrush (*Artemisia tridentata*) shrub/grassland with scattered Ponderosa Pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) [Nomenclature follows Douglas et al. 1998b, 1998c, 1999 and 2001]. The sites occur at the western edge of the distribution of open shrub/grassland at that elevation. Associates of *A. flagellaris* include Cushion Buckwheat (*Eriogonum ovalifolium* var. *nivale*), Parsnip-flowered Buckwheat (*E. heracleoides* var. *angustifolium*), Swale Desert-parsley (*Lomatium ambiguum*), Thread-leaved Sandwort (*Arenaria capillaris* ssp. *americana*), Slender Wheatgrass (*Elymus trachycaulus*), One-spike Oatgrass (*Danthonia unispicata*), Common Rabbit-brush (*Ericameria nauseosus* var. *speciosa*), and Cut-leaved Daisy (*Erigeron compositus* var. *glabratus*). No non-native species were found in association with *Antennaria flagellaris*.

Biology

Little information is available on the biology of *A. flagellaris* in British Columbia. Only basic reproductive facts have been compiled about the species.

Antennaria flagellaris is a short-lived perennial, dioecious (male and female structures on separate plants) and wind-pollinated. This species produces seeds sexually by outcrossing (Bayer 1996). The fruits consist of single-seeded achenes. The numerous hair-like bristles of the mature achene facilitate its dispersal by wind.

Antennaria flagellaris also reproduces vegetatively by producing stolons that terminate in plantlets. Initially, the mother plant provides the plantlet with nutrients via the stolon. The genetically identical plantlets eventually become independent plants as stolons are severed. This mode of reproduction results in very restricted dispersal, as stolons only grow up to 10 cm long (Douglas 1998).

Population Attributes

There are three recently surveyed populations of *Antennaria flagellaris* in the Similkameen River valley, south of Princeton, British Columbia (Table 1). These populations occur along a 3.2-km length of Highway #3 (Figure 2). The populations range from a couple of square metres to over 2100 m^2 in size and number from 50 to approximately 1 400 000 ± 100 000 plants.

Short- and long-term trends for these populations are unknown but can be expected to vary markedly due to differences in yearly plantlet survival, seed germination and seedling success. Growing conditions on the ephemerally moist, clay slopes may vary from year to year according to normal climatic fluctuations affecting site hydrology.

Provincial, National and Global Ranks

Globally, *Antennaria flagellaris* has a rank of G5? indicating that in most of its range the plant is apparently secure to demonstrably widespread, abundant, and secure. Since the species is restricted to British Columbia it has a national rank in Canada of N1. Provincially, *Antennaria flagellaris* has been ranked as S1 by the Conservation Data Centre and appears on the British Columbia Ministry of Environment Red list (Douglas et al. 2002a). This is the most critical rank that can be applied to species at the provincial level and indicates that the species is "critically imperiled because of extreme rarity (typically five or fewer occurrences or very few remaining individuals) or because of some factor(s) making it especially vulnerable to extirpation or extinction".

Threats and Protection

The major threat to populations of *Antennaria flagellaris* are through drilling for coalbed methane gas,

road construction, housing developments and off-road recreational vehicles. In 2002 three test holes, targeting coalbed methane gas deposits, were drilled in the Similkameen valley. If brought into production the drilling, access roads and pumping stations could cause major degradation in the area.

The southern interior of British Columbia has recently seen an increase in housing projects and the Princeton area is no exception. Any developments which even slightly change groundwater levels could be devastating to this taxon. Furthermore, suitable habitats for *A. flagellaris* are extremely restricted in Canada, only occurring in the Princeton area, thus opportunities for colonisation are extremely limited.

Although weeds are not a major threat to *A. flagellaris* populations, weed control activities do constitute a minor potential threat to populations. Under the *Weed Control Act*, an occupier must control noxious weeds growing or located on land and premises; thus marginally specific chemical weed control compounds, that kill broad-leaved plant species, would likely be fatal to *A. flagellaris*.

Recreational off-road vehicle use could also present a threat due to the nature of the steep, clay slopes where *A. flagellaris* occurs. When moist, this habitat would be highly susceptible to disturbance and at the same time, be at its most desirable to off-road users. Overuse of the habitat in this way could disturb the sites enough to radically alter the hydrological regime, and promote the establishment of non-native species.

Other potential threats result from activities that are permitted in the Agriculture Land Reserve. The private property where *A. flagellaris* occurs is on the Agricultural Land Reserve, where primary land use is agriculture. For instance, some types of fill/soil removal are allowable without application to the Agricultural Land Commission (Provincial Agricultural Land Commission 2003*). On these lands, development pressures may not appear to be an issue at this time. The Agricultural Land Reserve status may prevent subdivision development, but does allow other activities that could also potentially threaten the populations. In recent years many tracts of Agricultural Land Reserve land in southern British Columbia have been converted to housing developments, shopping malls, and golf courses, either by decisions of the Agricultural Land Commission or, very rarely, by an "order in council" by the sitting provincial legislature.

An additional threat to the population of *A. flagellaris* is its vulnerability to extirpation due to the extremely small occupied area and population size. Such small populations are at risk of inbreeding depression (Primack 1998). Due to lack of genetic variation, these small populations are vulnerable to demographic and environmental variation. Furthermore, suitable habitats for *C. flagellaris* in the southern interior of British Columbia are extremely limited and thus opportunities for colonisation are also limited.

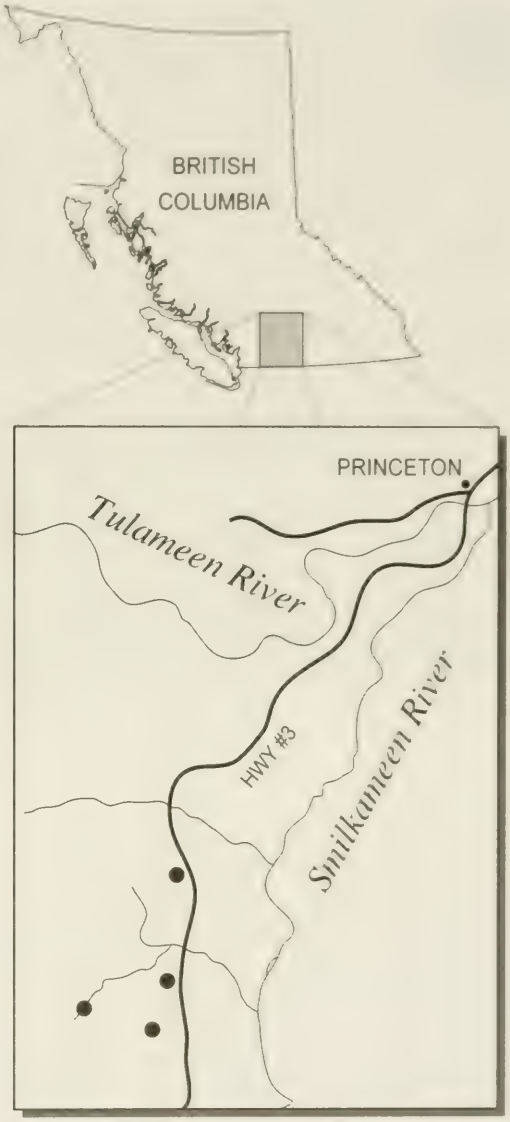

FIGURE 2. Distribution of *Antennaria flagellaris* in British Columbia.

Antennaria flagellaris is not formally protected in British Columbia, however, it could be in the future since this species is a potential candidate for listing under the provincial *Wildlife Amendment Act* (2004). As part of its commitment to the National Accord (*National Accord for the Protection of Species at Risk*), the province is required to take measures to protect this species. It is on Schedule 1 of the federal *Species At Risk Act* and a recovery strategy is expected to be completed by the summer of 2006.

FIGURE 3. Open habitat of *Antennaria flagellaris* in the Princeton area. *Antennaria flagellaris* is abundant in the open areas between clumps of *Eriogonum heracleoides* var. *angustifolium* and *Ericameria nauseosus* var. *speciosa*.

Evaluation

The British Columbia Conservation Data Centre considers *A. flagellaris* to be Endangered in British Columbia (Douglas et al. 2002a). The Committee on the Status of Endangered Wildlife in Canada has also assigned this species to the Endangered category (COSEWIC 2004*). The three populations are small and vulnerable to a number of threats. With limited knowledge of the plants, biological and ecological requirements, this species is vulnerable to extirpation in British Columbia. Without research on growth requirements and further demographic information, the stability of the present populations will remain unknown. The limited number of plants also reduces the potential for genetic variation which may be necessary to respond to environmental changes in the future.

Acknowledgments

We thank Frank Lomer for providing information on his original discovery of *A. flagellaris* and for his assistance in relocating the sites in 2002 and 2003.

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Late-born Elk, *Cervus elaphus*, Calf Observed Near Bancroft, Ontario

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A recently born male Elk (*Cervus elaphus*) calf was observed and photographed approximately 30 km east of Bancroft, Ontario, on 5 October 2004. Based on the gestation period for Elk, the estimated conception date was between late December 2003 and early January 2004. This is unusual as the majority of calves are born between late May and early June with conception having occurred in September/October. This reproductive strategy allows for an optimum growth period for calves to occur before the onset of winter which increases the probability of survival. An eleven-year-old cow Elk was identified as the mother of the late born calf. The age of the cow, and her inability to meet the annual energy requirements necessary for normal reproduction, may have contributed to the late conception and parturition dates.

Key Words: Elk, *Cervus elaphus,* Elk calf, restoration, late-born, Ontario.

In 1998, the Ontario Ministry of Natural Resources (OMNR) and partner organizations implemented a plan to restore Elk (*Cervus elaphus*) to Ontario, Canada (Bellhouse and Broadfoot 1996). Between 1998 and 2001, 443 elk acquired from Elk Island National Park (EINP), Alberta, were released in four different areas of Ontario; Lake of the Woods, Lake Huron/North Shore (near Blind River), French River/Burwash, and Bancroft/North Hastings (Rosatte et al. 2002). In total, 120 Elk were released during 2000/2001 in the Bancroft/North Hastings area at a location near Gin Lake (UTMC = 304000E 4990000N). Each summer, Elk calves have been observed and each winter, Elk calf surveys were conducted using OMNR helicopters to determine Elk calf survival and estimate the size of the herd.

On 5 October 2004, a male Elk calf with spots, estimated to be about three weeks of age, was observed and video taped near Hartsmere, Ontario (UTMC= 300000E 4995000N), approximately 25 km east of Bancroft, Ontario (Figure 1). The calf weighed about 25-30 kg based on body size; average birth weights for Elk calves are 15-22 kg (Hudson et al. 2002). On 1 November 2004, the calf was again observed nursing from a 11-year-old cow Elk which had been ear-tagged (All-Flex ear-tag # 347), weighed (238 kg), and radio-collared (Lotek GPS Collar- 148.115 Mhz) at EINP, Alberta, and released in the Bancroft/North Hastings, Ontario, area during April 2001. The calf was observed nursing from the cow during December 2004 and January 2005. The calf, still with spots, was photographed again on 1 February 2005, near Hartsmere, Ontario (Figure 2). It was with a group of 38 Elk comprised of 13 bulls {4 mature (>5yr), 4 yearlings, 5 immature (2-4 yrs), 8 calves, and 17 cows (which included the calf's mother – Figure 3)}. Based on observation during January/February 2005 the late-born calf with spots was estimated to be 25%-35% smaller than the other calves (Figure 2). Those calves were of a size comparable to Elk calves handled at EINP, Alberta, where calf weights averaged 120 kg (264 lb) (n=16) during January 2001. These weights are comparable to 8-9 mo old Elk calves in other studies that were born during early spring and summer (Cook 2002; Peek 2003). Unfortunately, the spotted calf was killed on 25 February 2005. Based on tracks in the fresh snow, injuries to the calf, and blood on the antlers of a mature bull Elk, the calf was likely gored to death.

Gestation periods for Elk range between 247-262 days with a mean of about 255 days (Bubenik 1982; Hudson et al. 2002). As this calf was first observed on 5 October 2004, conception must have occurred during late December 2003 or early January 2004. Wishart (1981) reported a cow Elk in Alberta that was shot in September 1979 and had a fully developed fetus. In this case, the conception date was estimated to be January 1979 and the cow was estimated to be 10 years of age. In Elk, reproductive success generally declines after 7 years of age (Raedeke et al. 2002).

One adaptive strategy of Elk is the production of highly developed, rapid growing, large young, so that calves quickly reach a size that maximizes survival during winter (Geist 2002). The high energy requirements for rapid growth of Elk calves is met through the energy acquired from maternal milk. Elk calves acquire most of their nutritional requirements during their first month of life from milk; however, after this neonatal period, requirements are greater and the ingestion of solid forage is required. That is why parturition throughout most of Elk range is early spring and summer (late May/early June) when forage is high in protein and nutritious (Hudson et al. 2002). The timing

FIGURE 1. Late born elk calf with spots photographed by J. Neuhold near Hartsmere, Ontario, on October 5, 2004.

of calving for Elk is such that inclement winter/spring weather is avoided but is early enough (e.g. June) so that calves can attain sufficient weight and size to survive the winter (Hudson et al. 2002). Juvenile Elk have evolved to reduce or cease growth during fall and winter, when the nutritive value of forage declines. Cook et al. (1996) reported that calf growth in mid-November was 50% of that found in September and hypothesized that the nutritional strategy of Elk calves during the late fall/early winter was primarily to maintain condition rather than maximizing growth. Inevitably, energy acquisition for rapid growth becomes a problem for late-born calves, as not only is forage less nutritious during the fall and winter, but milk production in lactating cow Elk also declines during that period due to poor quality forage (Cook et al. 1996; Cook 2002). In addition, survival was found to be lower for late-born Elk calves in Yellowstone National Park than for earlier-born calves (Singer et al. 1997), and calf mortality during winter was primarily due to malnutrition. The calf in this study was observed nursing in mid-January 2005 and supplemental feeding by people in the area may have provided sufficient energy for the cow to continue milk production during the winter period.

Nutrition and lactation can affect the timing of estrous in Elk and subsequently the parturition date (Cook 2002). Generally, cows that are suckling a calf during the rut come into estrous later than cows that do not have a calf (Hudson et al. 2002). During the early part of rut, estrous approximates 21 days but is variable (19-25 days) (Bubenik 1982) and estrous length increases and becomes irregular during the later stages of the breeding period (Hudson et al. 2002). Three to four estrous periods during one breeding season are possible with a refractory period of 62 days between sequential estrous cycles (Bubenik 1982) and Elk can be in heat as late as February. Older aged ungulates often cannot support production or reproduce (Cameron 1994; Cook 2002). Generally, reproductive success for elk 11 years of age is low (Raedeke et al. 2002). The age of the cow in this study, and her inability to meet the annual energy requirements necessary for normal reproduction, may have contributed to the late conception and parturition dates.

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FIGURE 2. Late born elk calf with spots was about 25% smaller than other calves when photographed by R. Rosatte near Hartsmere, Ontario, 1 February 2005.

FIGURE 3. Elk calf with spots with 11-year old mother (on right) (photo by R. Rosatte near Hartsmere on 1 February 2005).

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Annual Variation in Habitat Use by White-footed Mice, *Peromyscus leucopus*: The Effects of Forest Patch Size, Edge and Surrounding Vegetation Type

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White-footed Mice (*Peromyscus leucopus)* were trapped for two years in the exterior matrix, edge, and interior forest habitat sections of six forests patches in a fragmented agricultural landscape. We used data on the capture locations of *P. leucopus* individuals from the two years, which differed in rainfall (i.e., summer of 2000 with 50% more rain than summer of 1999), to assess how patch size, edge habitat, and surrounding habitat type influence habitat use and movements in populations of this forest habitat generalist. We found that the proportion of individuals subsequently captured in the forest edge from the exterior was 16 times greater in the wet year than in the dry year and approximately twice as many *P. leucopus* were not subsequently recaptured from the exterior matrix in the dry year compared to the wet year. For each year, captures between habitats did not differ in relation to patch size, edge forest habitat, or exterior matrix type. These results illustrate the generalist habitat preferences of *P. leucopus,* but emphasize annual variation in their behavior and distribution.

Key Words: White-footed Mice, *Peromyscus leucopus*, forest patches, habitat preference, edge habitat, exterior matrix, Ohio, Indiana.

Human activities have led to a reduction and fragmentation of secondary-growth deciduous forests in North America, as well as changes in the quality of the remaining habitat (Yahner 1988; Fahrig 1997). The effects of fragmentation include those related to loss of connectivity among remnant patches, and increases in edge habitat, which both can cause local changes in abundance, distribution, and species' persistence (Andren 1994, 1997; Murcia 1995). In addition, the fragmentation of forested habitat results in the creation of forest patches that vary in size. Studies have shown that there are taxonomic differences in the relationship between animal population densities and patch area. Insects and birds generally show a positive relationship, likely due to an avoidance of edge habitat, which is greater in proportion in smaller patches (Connor et al. 2000). The majority of mammal species show fairly constant population densities with patch area, this follows the theory of island biogeography (Bowers and Matter 1997).

In contrast, investigators have found a consistent negative relationship between density of the White-footed Mouse (*Peromyscus leucopus* Rafinesque), a forest habitat generalist, and forest patch area (Nupp and Swihart 1996, 1998; Krohne and Hoch 1999; Mossman and Waser 2001; Schmid-Holmes and Drickamer 2001; Anderson et al. 2003; Anderson and Meikle 2006). Although resource availability may influence population dynamics of small mammals (e.g., Nupp and Swihart 1996), there are other factors that may be responsible for the negative density-area relationship. One possibility is that dispersal is inhibited from smaller forest patches due to lower habitat quality in the matrix than under continuous forest cover (Brown and Litvaitis 1995; Nupp and Swihart 1998; Krohne and Hoch 1999). We hypothesize in the current study that if inhibited dispersal results in the negative density-area relationship, then fewer *P. leucopus* should tend to move from the forest edge to the agricultural fields surrounding smaller compared to those surrounding larger forest patches.

In addition to patch area, another consequence of forest fragmentation is an increase in the proportion of edge habitat in the landscape since smaller forest patches have a greater edge: interior ratio than larger forest patches. Forest edges usually exhibit differences in microclimate, species composition, and vegetation structure compared to forest interiors (Harris 1988; Saunders et al. 1991). These difference may influence abundance and distribution of animal species. Studies have found that some forest animals may prefer forest edges while others may avoid those areas (Harris 1988; Saunders et al. 1991; Murcia 1995). However, there is debate as to whether *P. leucopus* prefers forest edge to forest interior habitat. Some investigators have reported greater densities of *Peromyscus* spp. near edges (Cummings and Vessey 1994; Boyne and Hobson 1998; Manson et al. 1999), possibly because

vegetation in edge habitat has been shown to be structurally more complex compared to interior habitat (Cummings and Vessey 1994; Anderson et al. 2003). In contrast, others have found fewer mice and lower maternal survival and litter success in edge habitats, presumably because parasitism, predation and interspecific competition can be higher along edges (Matter et al. 1996; Morris and Davidson 2000; Wolf and Batzli 2001, 2004). Since there is no evidence to date of higher rates of predation on mice in forest edges, then we predict that mice may prefer the high quality vegetation in forest edges such that there would be higher recapture rates in forest edges than in forest interiors.

Another consequence of forest fragmentation is that forest patches are surrounded by a matrix of agriculture or residential development that may inhibit the movement of organisms (Fitzgibbon 1997; Collinge 1996). Even though the agricultural matrix surrounding forest patches may be considered "hostile" habitat for some species (Collinge 1996), generalists such as *P. leucopus* (Gottschang 1981) may disperse relatively easily (Lackey 1978) through row crop fields (Mossman and Waser 2001). However, it is not well understood whether matrix types (e.g., corn or pasture) differentially affect capture rates of White-footed Mice in the exterior matrix. M'Closkey and Lajoie's (1975) work suggests that *P. leucopus* may prefer corn over pasture because mice were absent from grasslands. Even though grasses may provide cover for mice from aerial predators, Getz (1961) also noted that individual *Peromyscus* avoided grassy sites under forest canopy (also see M'Closkey and Lajoie 1975) likely because it rustles as the mouse moves (Barnum et al. 1992). If surrounding habitat type influences movements of mice throughout the landscape, we predict that they may stay in or move into the surrounding matrix habitat at greater rates when the matrix is comprised of corn rather than pasture.

The purpose of this study was to use data on the first two captures of *P. leucopus* individuals in different habitats (i.e., exterior matrix, forest edge, and forest interior habitat) in small and large forest patches for two summers to test the hypotheses related to patch size, edge habitat, and surrounding habitat type as described above. In addition, we compared captures among habitats between two summers differing in rainfall amounts (i.e., one dry year and one wet year) because temporal variation in precipitation regulates rodent population dynamics (Lewellen and Vessey 1998). Utilizing data on habitat use instead of overall abundance, we assumed that if mice tended to prefer one habitat over another, then, on average, they would move into (or stay in) the preferred habitats in relatively high proportions. Since much of the work on the effects of forest fragmentation has been focused on birds, this study contributes to our understanding of how human-dominated landscapes influence habitat use and movements of populations of small mammals.

Methods

Study Area

Peromyscus leucopus were trapped in both 1999 and 2000 in the same three "small" (~5-9 ha) and three "large" (~110-150 ha) forest patches in a row-crop agricultural landscape covering approximately 144 km^2 in SW Ohio and SE Indiana, USA (study area, 39°51'N, 84°74'W; Anderson and Meikle 2006; Table 1). We analyzed data from four transects of six Sherman™ live traps (7.5 × 7.5 × 25.5 cm) that were placed perpendicular to the center of one edge of each patch, with each transect beginning 20 m exterior to and extending 30 m into the patch (Figure 1). The transects and the traps in each transect were spaced 10 m apart, resulting in a 30 m by 50 m grid with a total of 24 traps at each forest patch. The eight traps in the agricultural field outside of each forest patch were considered "exterior" and the next eight traps were considered "edge". The eight traps inside the forest patch were considered "interior" traps. Based on our previous findings (Anderson et al. 2003) and corroborated by Burke and Nol (1998), the width of the edge habitat was defined based on typical edge floristic features. The surrounding habitat type in the exterior matrix was either pasture or corn fields (Table 1).

Data collection

Traps were set on 26 nights in each forest patch between June and September in 1999 and 2000 for a total of 7488 trap-nights. When a mouse was captured initially it was lightly anesthetized with halothane and a 12 mm AVID® microchip (PIT tag) was injected under the scruff of its neck. To distinguish between *P. leucopus* (primarily a woodland species) and *P. maniculatus* (primarily a grassland species), which are morphologically similar and overlap in the nonforested habitat within the study area, saliva samples were analyzed for the migration of the amylase enzyme with polyacrylamide gel electrophoresis (Aquadro and Patton 1980; Bruseo et al. 1999). We followed the protocol of Bruseo et al. (1999) with minor modifications.

Each patch was trapped for two consecutive nights every 5-7 d and we recorded the date, identification number and location of every individual at every trapping event. Based on trap location we determined which habitat (i.e., exterior, edge, or interior) each individual was located in for its first capture and then where it was subsequently captured for its second capture event. It is possible that the length of time between any two capture events for a particular individual could be 24 hours apart or more. A fourth category for the subsequent capture was "not subsequently recaptured", which was used if the individual was not recaptured again after tagging. Only the first two capture events for each individual were analyzed so that each individual was included only once in the analysis to avoid pseudoreplication. In order to verify whether a mouse moving into a particular habitat reflects fidelity to this

TABLE 1. Description of study sites and their location, size, and surrounding habitat type (i.e., exterior matrix habitat) in 1999 and 2000.

Patch names	Location	Size (ha)	Surrounding habitat type 1999	2000
Small patches				
ERC (Ecology Research Station)	Oxford, Ohio	5	pasture	pasture
Indiana	Bath, Indiana	8	corn	corn
Jericho	Oxford, Ohio	9	corn	corn
Large patches				
Bachelor Woods and Game Preserve	Oxford, Ohio	150	pasture	pasture
Hueston Woods State Park	Preble/Butler Counties, Ohio	200	corn	pasture
Reily Township	Reily, Ohio	110	corn	soybeans*

*This patch was not included for tests involving surrounding habitat type since it was the only patch with soybeans.

habitat shift, we also analyzed the data for the first year using all captures of all mice instead of the first two capture events only (i.e., 188 mice captured a total of 901 times) and found similar results (not presented), suggesting a permanence of habitat shifts. Although over winter survival was very low (i.e., four known individuals) between the two years of this study (Anderson 2004), we did not include those four individuals in the data set for the second year. Rainfall amounts from the Ohio Agricultural Research & Development Center (OARDC) weather station on Miami University's Oxford campus (http://jrscience.wcp.muohio.edu/van tagepro/latestweather.html) were totaled for each summer month (June – August) in 1999 and 2000. The OARDC is located within the center of the study area.

Statistical analyses

Data on the proportion of mice trapped for their second capture in the exterior, edge, or interior habitats, or not subsequently recaptured, based on the three initial capture habitats (i.e., exterior, edge, or interior) were compiled (see Table 2). The data set was analyzed with PROC CATMOD using chi-square tests to determine whether captures among habitats differed in relation to patch size, surrounding matrix type, and year (SAS 1999-2000). Subsets of the data were analyzed with PROC FREQ using either chi-square tests or Fisher's exact tests when sample size was small ($n < 50$ or cells with values < 5; SAS 1999-2000). Data from each year were analyzed separately (see Results; Table 2). In post hoc analyses, Fisher's exact tests and chi-square tests were used where appropriate (Moore and McCabe 1993) with a Bonferroni adjustment to the level of sig-

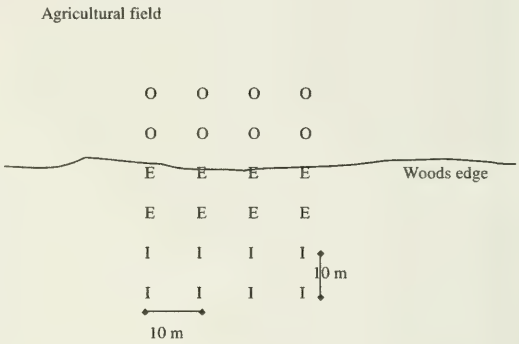

FIGURE 1. The trapping grid design for each of the forest patches in this study. The letter "O" denotes each outside (i.e., exterior) trap, the letter "E" represents the eight edge traps, and the "I" denotes the interior trap locations.

TABLE 2. The habitat where each *Peromyscus leucopus* was trapped for its second capture based on where it was first captured in 1999 and 2000. Values are pooled across patch sizes and number of individuals and row percentages are given in parentheses.

Habitat where first captured	Habitat where subsequently (i.e., second) trapped			
1999	Exterior	Edge	Interior	Not subsequently recaptured
Exterior	9 (28%)	1 (3%)	2 (6%)	20 (63%)
Edge	6 (14%)	19 (43%)	10 (23%)	9 (21%)
Interior	2 (4%)	8 (15%)	17 (31%)	27 (50%)
2000	Exterior	Edge	Interior	Not subsequently recaptured
Exterior	1 (8%)	6 (50%)	1 (8%)	4 (33%)
Edge	1 (3%)	18 (46%)	10 (26%)	10 (26%)
Interior	0 (0%)	7 (13%)	23 (41%)	26 (46%)

nificance at $\alpha = 0.05$ (Sokal and Rohlf 1981). An unpaired t-test was used to test for a difference in mean monthly rainfall in the summer (June – August) of 1999 compared to 2000 (Sokal and Rohlf 1981).

Results

Patch size did not influence captures of *P. leucopus* among habitats in either 1999 or 2000 (1999: $\chi^2_3 = 0.9$, $P = 0.8$; 2000: $\chi^2_3 = 4.7$, $P = 0.2$). Hence, there was no difference in captures of mice among different habitats (i.e., exterior matrix, edge, or interior habitats, or not subsequently recaptured) for those individuals that had been initially trapped in edge habitat in small compared to large patches in either year (1999: Fisher's exact test, $n = 44$, $P = 0.5$; 2000: Fisher's exact test, $n = 39$, $P = 0.7$). Data were pooled across patch sizes within each year for all other analyses (Table 2). The proportion of *P. leucopus* recaptured in edge habitat (i.e., both the first and second captures occurred in edge habitat) compared to the proportion recaptured in interior habitat did not differ in either year (1999: $\chi^2_1 = 1.4$, $P = 0.2$; 2000: $\chi^2_1 = 0.2$, $P = 0.6$), suggesting that mice did not show a preference for edge or interior forest habitat. Surrounding habitat type (i.e., corn or pasture) did not influence the proportion of mice subsequently captured across different habitats that had been first captured in the edge in either year (1999: Fisher's exact test, $n = 44$, $P = 0.5$; 2000: Fisher's exact test, $n = 33$, $P = 0.2$). Likewise, surrounding habitat type did not affect subsequent captures across habitats for mice that had been first captured in the exterior matrix habitat in either year (1999: Fisher's exact test, $n = 32$, $P = 0.3$; 2000: Fisher's exact test, $n = 10$, $P = 0.3$).

When captures between habitats in 1999 and 2000 were compared, *P. leucopus* first captured in the exterior were subsequently trapped in different proportions among habitats in 1999 compared to 2000 (Fisher's exact test, $n = 44$, $P = 0.002$); specifically, the proportion of individuals subsequently captured in the forest edge from the exterior was 16 times greater in 2000 (6/12 = 50%) than in 1999 (1/32 = 3%; Fisher's exact test, $n = 44$, $P = 0.0008$; Table 2, Figure 2a). Likewise, a greater proportion of mice stayed in the exterior matrix compared to moving into the forest (edge and interior combined) in 1999 (9/12) than in 2000 (1/7; Fisher's exact test, $n = 20$, $P = 0.02$). Approximately twice as many *P. leucopus* were not subsequently recaptured after their first capture in the exterior matrix in 1999 (20/32 = 63%) compared to 2000 (4/12 = 33%), although the test was not significant (Fisher's exact test, $n = 44$, $P = 0.1$; Figure 2b). Mean monthly rainfall amounts were over 50% higher in the summer (June-August) of 2000 (mean ± SE = 11. 8 ± 0.9 cm) compared to 1999 (5.3 ± 1.0 cm; $t_4 = 4.7$, $P = 0.009$).

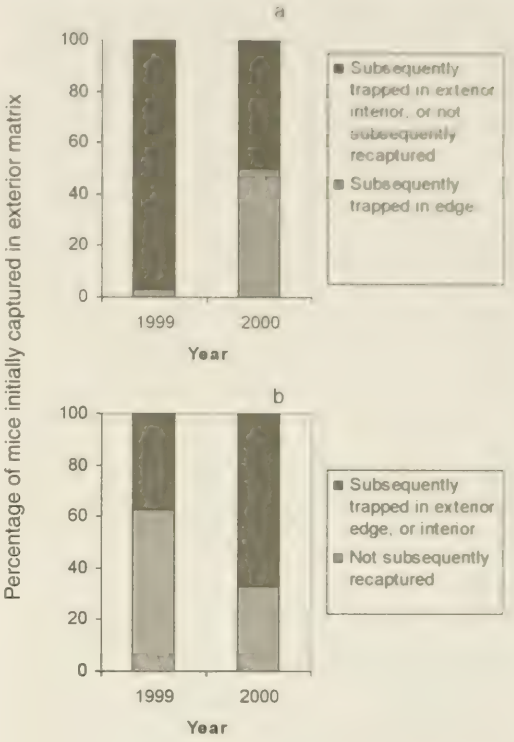

FIGURE 2. Percentage of mice (a) subsequently captured in forest edge habitat in 1999 compared to 2000 and (b) not subsequently recaptured in 1999 compared to 2000 (see Table 2 for sample sizes) that had been initially trapped in the exterior matrix habitat.

Discussion

Patch size

Studies have shown that populations of *P. leucopus*, unlike birds, insects, and most other mammals, have greater densities in smaller forest patches (Nupp and Swihart 1998; Krohne and Hoch 1999; Anderson et al. 2003). One proposed mechanism to account for this negative density-area relationship is that habitat quality is lower in the exterior matrix than in woodland sites (Nupp and Swihart 1996; Krohne and Hoch 1999). Predation pressure may be elevated in the agricultural fields surrounding smaller patches because some predators may attain higher densities in a landscape with a variety of land uses (Brown and Litvaitis 1995). We predicted that fewer mice would move from the forest edge to the agricultural fields surrounding smaller than larger forest patches, but our results did not support the inhibited dispersal hypothesis. Diaz et al. (1999) found no difference in movements of *Apodemus sylvaticus* to the exterior in relation to patch size, whereas Krohne and Hoch (1999) found that *P. leucopus* populations in Indiana had lower dispersal rates from smaller patches, a factor that may have resulted in higher densities in those patches (Adler and Levins 1994). Nupp and Swihart (1996) concluded that both reduced dispersal and greater abundances of food contributed to the high densities of *P. leucopus* they observed in small forest woodlots.

It is unclear why densities of *P. leucopus* tend to be higher in small forest patches (Anderson and Meikle 2006). One possibility is that immigration rates are in fact greater into smaller forest patches, resulting in higher densities in those patches (Bowman et al. 2002). However, we did not find that movements from exterior to the edge or interior habitats were greater in smaller than larger patches in this study. If smaller and larger forest patches do not vary in emigration and immigration rates, as our data suggest, then a second possibility is that other factors, such as greater food abundance or cover from predators, may have resulted in greater abundances of mice in smaller patches or in particular the edges of small patches (Nupp and Swihart 1996; Diaz et al. 1999; Anderson et al. 2003; Anderson and Meikle 2006). A third possibility is that lower densities in larger patches may be the result of mice dispersing to low density regions within the heterogeneous forest patch to alleviate high densities, with fewer sites likely present in smaller forest patches (Krohne and Burgin 1990; Krohne and Hoch 1999).

Edge habitat

Differences in species composition and vegetation structure in forest edges compared to forest interiors, regardless of patch size; may influence the distribution of small mammals within forest fragments (Matlack 1994; Collinge 1996). Currently, there are conflicting reports about the effects of edge habitat on the abundance and distribution of White-footed Mice (e.g., Cummings and Vessey 1994; Anderson et al. 2003; Wolf and Batzli 2004). We found that *P. leucopus* were recaptured in the same proportion in forest edge compared to forest interior habitat in either year. Our data on initial and second capture habitat locations support those studies that reported no difference in the relative abundance of mice in those two habitats (Heske 1995; Nupp and Swihart 1996, 1998). This result is somewhat surprising since forest edge habitats have been shown to have greater structural complexity in the understory vegetation compared to edge habitat (Anderson et al. 2003) and White-footed Mice have been shown to prefer areas with more plant cover (Drickamer 1990). One explanation could be that mice are not moving into edge habitat but are already present in high abundances with small territory sizes. Perhaps once territories are established in early spring, when movements among high (i.e., edge) and low quality (i.e., interior) habitats are negligible due to competitive exclusion.

Surrounding habitat type

Types of vegetation in the surrounding matrix habitat may differentially affect the population dynamics of rodent species in a fragmented landscape. For example, Wolf and Batzli (2004) found that predation risk for *P. leucopus* was higher at edges adjacent to restored prairies than at edges adjacent to agricultural fields. Our findings showed that *P. leucopus* moved in similar proportions from the forest edge into two different matrix habitat types (i.e., corn and pasture). This is in contrast to studies that have found that *P. leucopus* tend to avoid grassy habitats and can be found in corn fields at densities as high as those in woodlots (Getz 1961; M'Closkey and Lajoie 1975; Wegner and Merriam 1979, 1990). Mice in our study sites may have simply responded to the seasonal presence of cover and not to the type of cover (Cummings and Vessey 1994). Henein et al. (1998) designed a simulation model illustrating flexible and opportunistic responses of *P. leucopus* to landscape structure and connectivity via an expansion of their use of corn and small grain fields. Similar results have been found for *A. sylvaticus*, a mouse species also described as a habitat generalist (Garcia et al. 1998; Kozakiewicz et al. 1999).

Annual variation

Rainfall may impact rodent populations directly by influencing their reproductive status and survival, or indirectly in relation to changes in food sources and vegetative cover from predators (Kaufman et al. 1995; Kesner and Linzey 1997). Monthly rainfall data showed that totals in the summer of 2000 were almost 50% greater than in 1999. For mice initially captured in the exterior matrix habitat, we found that a greater proportion moved to the edge habitat and more were subsequently recaptured in the exterior matrix in the wet year compared to the dry year. If rainfall influenced patterns of capture among habitats, one explanation is that in 1999 (i.e., the dry summer) a higher proportion of mice were not subsequently recaptured from the exterior matrix habitat because they died due to poor conditions, or moved throughout the landscape in search of other better quality habitats (Kesner and Linzey 1997; Lidicker and Stenseth 1992). In 2000, the shrub and herbaceous layers in the forest habitat may have had more or higher-quality food sources compared to the exterior matrix as a consequence of rainfall which caused an influx of mice to the forest habitat (Parmenter and MacMahon 1983; Bowers and Dooley 1999; Hutchinson et al. 1999). Our results illustrate the generalist habitat preferences of *P. leucopus* but emphasize annual variation in their distribution within the forest and surrounding habitats. However, year-to-year differences in patterns of habitat use may be influenced by a number of variables, and a longer-term study would help to elucidate those factors (Kesner and Linzey 1997).

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Response of the Sea Louse *Lepeophtheirus salmonis* Infestation Levels on Juvenile Wild Pink, *Oncorhynchus gorbuscha*, and Chum, *O. keta*, Salmon to Arrival of Parasitized Wild Adult Pink Salmon

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Recent recurring infestations of Sea Lice, *Lepeophtheirus salmonis*, on juvenile Pacific salmon (*Oncorhynchus* spp.) and subsequent annual declines of these stocks have made it imperative to identify the source of Sea Lice. While several studies now identify farm salmon populations as sources of Sea Louse larvae, it is unclear to what extent wild salmonid hosts also contribute Sea Lice. We measured Sea Louse numbers on adult Pink Salmon (*Oncorhynchus gorbuscha*) migrating inshore. We also measured Sea Louse numbers on wild juvenile Pink and Chum salmon (*Oncorhynchus keta*) migrating to sea before the adults returned, and as the two age cohorts mingled. Adult Pink Salmon carried an average of 9.89 (SE 0.90) gravid lice per fish, and thus were capable of infecting the adjacent juveniles. Salinity and temperature remained favourable to Sea Louse reproduction throughout the study. However, all accepted measures of Sea Louse infestation failed to show significant increase on the juvenile salmon, either in overall abundance of Sea Lice or of the initial infective-stage juvenile lice, while the adult wild salmon were present in the study area. This study suggests that even during periods of peak interaction, wild adult salmon are not the primary source of the recent and unprecedented infestations of Sea Lice on juvenile Pacific Pink and Chum salmon in the inshore waters of British Columbia.

Key Words: Sea Lice, *Lepeophtheirus salmonis* Pink Salmon, *Oncorhynchus gorbuscha* Chum Salmon, *O. keta*, salmon farm, British Columbia

The sea louse *Lepeophtheirus salmonis* is a common salmon-specific parasite (Nagasawa et al. 1993; Kabata 1973). While their preferred Pacific host is the Pink Salmon (*Oncorhynchus gorbuscha*) (Nagasawa 1987; Nagasawa et al. 1993), *L. salmonis* is found on all species of Pacific salmonids, as well as Atlantic Salmon (*Salmo salar*), Sea Trout (*Salmo trutta trutta*), Rainbow Trout (*Salmo gairdneri*) and Artic Charr (*Salvelinus alpinus*). Once considered benign (Boxshall 1974; Nagasawa 1987; Berland 1993), *L. salmonis* is now a significant problem species on farmed salmon (Pike and Wadsworth 1999; Johnson et al. 2004). Salmon farms are a series of floating net pens attached to the shoreline or anchored in the nearshore. Salmon arrive from hatcheries and are fed in these pens for 18-24 months, then harvested and sold as food. All farm salmon in our study area were Atlantic Salmon.

Optimal salinity for *L. salmonis* survivorship and reproduction is 30‰ (Johnson and Albright 1991b), with copepodids tolerating salinities as low as 15‰ (Pike and Wadsworth 1999). *L. salmonis* hatch into a free-swimming naupliar stage directly from egg strings attached to the female's body (Johnson and Albright 1991a). The interval from hatching to infective capability (copepodid stage) is approximately 4 d at 10°C and 2 d at 15°C (Johnson and Albright 1991b). The copepodid stage is the first attached stage, thus abundant presence of this stage signals a local source of gravid Sea Lice and a host salmonid population. When wild salmon enter freshwater to spawn, the attached *L. salmonis* experience decay of life-processes leading to death (Hahnenkamp and Fyhn 1985; McLean et al. 1990; Johnson and Albright 1991b). As one would expect from an obligate parasite, there have been no reports of *L. salmonis* over-wintering off-host in the nearshore marine environment.

While early studies on juvenile wild Atlantic salmonids *Salmo salar* and *Salmo trutta* make no mention of parasitism by *L. salmonis* (Heuch and Mo 2001); Sea Lice are now reported in high numbers on wild European salmonids adjacent to farms (Tully et al. 1993; Birkeland 1996). Historically, researchers did not look specifically for *L. salmonis* on juvenile Pacific salmon in the inshore environment. However, the seminal works on juvenile Pink and Chum salmon (Healey 1978, 1982; Parker 1965; Parker and Vanstone 1966) did note the presence of the smaller sea louse, *Caligus clemensi* (Parker and Margolis 1964). *C. clemensi* is a generalist non salmon-specific parasite that has been reported on 13 species of fish (Jones and Nemec 2004*). It seems reasonable that if *Caligus* was noted, then the larger, more conspicuous *L. salmonis* would also have been reported had it been historically present on juvenile Pink salmon.

Today, Sea Lice are reported on juvenile Pink and Chum salmon in some areas of coastal British Colum-

bia and appear associated with salmon farming (Morton and Williams 2003; Morton et al. 2004; Morton et al. 2005; Krkosek et al. 2005; Krkosek et al. 2006). The impact of Sea Lice is host-size dependant (Grimnes and Jakobsen 1996; Bjørn and Finstad 1997) and this is critical to Pink and Chum salmon as they enter the marine environment at the smallest size of any salmonid. Pink and Chum Salmon weigh less than one gram in the study area (Broughton Archipelago) throughout March and April (Morton et al. 2005), and are without protective scales (A.M. personal observations). Juvenile Pink and Chum salmon exhibit prolonged inshore residency from March to September (Healey 1978). If some adult wild salmonids occur inshore year round, their numbers are low. The largest wild host population for *L. salmonis* are the mature Pink Salmon that enter coastal waters in July and run through September (Heard 1991).

Thus, in a natural setting, a system has evolved that isolates returning adult salmon from the most juvenile stage conspecifics. Juvenile Pink and Chum salmon do not share habitat with a significant *L. salmonis* host population until July, by which time they have grown to weigh several grams. Krkosek et al. (2005) report that after initial infection by salmon farms, juvenile salmon schools will re-infect themselves some weeks later as lice mature and being reproducing.

Salmon farming has altered this arrangement by siting 26 salmon farms in the nearshore environment of the Broughton Archipelago (Figure 1), each site holding potentially 1 million Atlantic Salmon (Naylor et al. 2003), a known host for *L. salmonis*. In July of 2003 there were approximately 6 million Atlantic Salmon among the 17 farm sites leased by Stolt Sea Farms with another nine sites leased by another company (Heritage) that did not report numbers (Orr *in press*). Orr (*in press*) reports an average of 2.2 – 9.2 gravid Sea Lice per salmon on the 6 million farm Atlantic Salmon for 2003-2004.

While salmon farms are now a recognized source of Sea Lice, this study further illuminates this subject by measuring the response in Sea Louse numbers on wild juvenile salmon to the arrival of a large population of this Sea Louse's preferred host, the adult Pink Salmon. We hypothesise that if wild adult salmon were a substantial source of Sea Lice on juvenile salmon in the study area, then the number of copepodid *L. salmonis* should rise in response to the arrival of in-migrating adult Pink Salmon. To test this, we first measured lice levels on juvenile Pink Salmon, then looked for evidence of copepodid Sea Louse recruitment subsequent to wild adult Pink Salmon arrival in the area.

Understanding the mechanisms of *L. salmonis* infestation of inshore juvenile wild salmon and the relative importance of both wild and farm lice sources has become crucial to both wild and farm salmon management. This study provides analysis on a previously unreported aspect of the dynamic between adult and juvenile Pacific salmon and Sea Lice.

Methods

This study took place in the 400 km^2 Broughton Archipelago in British Columbia. There are seven major Pink Salmon rivers and 26 Atlantic Salmon farm sites between the rivers and the open waters of Queen Charlotte Strait (Figure 1). The Broughton Archipelago's 200 km of inlets and 90 km of passages and small bays makes it ideal marine rearing habitat for juvenile Pink and Chum salmon (Healey 1978). Within this region, Fife Sound (Figure 1) through Tribune Channel is considered a primary route used by returning adult Pink Salmon (G. Neidrauer, Fisheries and Oceans Canada, Fisheries Patrolman, General Delivery, Simoom Sound, BC V0P 1S0 personal communication).

Juvenile Pink and Chum salmon were sampled once each week at the same sampling location from 1 June 2003 through 19 September 2003 (Figure 1). The salmon farm at this site was fallow, and without any farm salmon. A 50' × 4' beach seine of ⅛" mesh was used in June and a 120' × 8' beach seine with ¼" mesh and a ⅛" bunt was used for the remainder of the study. Sample size ranged from 20 to 30 fish per week. The juvenile salmon were placed individually in Whirlpak™ bags immediately after capture, laid on ice and then frozen. They were later examined under 30× magnification and the number of Sea Lice, their age-class and sex were determined and recorded using published taxonomic keys (Johnson and Albright 1991a). Adult female lice were classified as either virgin or gravid as per the Norwegian method of counting sea lice (Karin Boxaspen, Researcher, Institute of Marine Research, Bergen, Norway). Results are reported only for the salmon-specific Sea Louse, *L. salmonis*.

We used three independent methods to estimate the timing of the wild adult Pink Salmon return to the study area. First, we used measured Pink Salmon catch-per-unit directly at our juvenile salmon sampling site. We used two fishing rods with lures known to attract Pink Salmon in this area (A.M. personal observations). We fished for 166 hook-hours between 4 June and 19 September.

The second method compared our catch-per-unit-effort analysis with the timing of the adult return reported by Fisheries and Oceans Canada (DFO) as determined by their enumeration program on the known Pink Salmon-bearing streams nearby (Figure 1). The Fisheries and Oceans Pink Salmon enumeration flights began in the second week of August and continued through the end of October. Finally, a tourism operator in the Glendale River watershed (Figure 1) had guides on the river for 3 days in May, 11 days in June, 23 days in July, 28 days in August, and reported to us when Pink Salmon were first sighted.

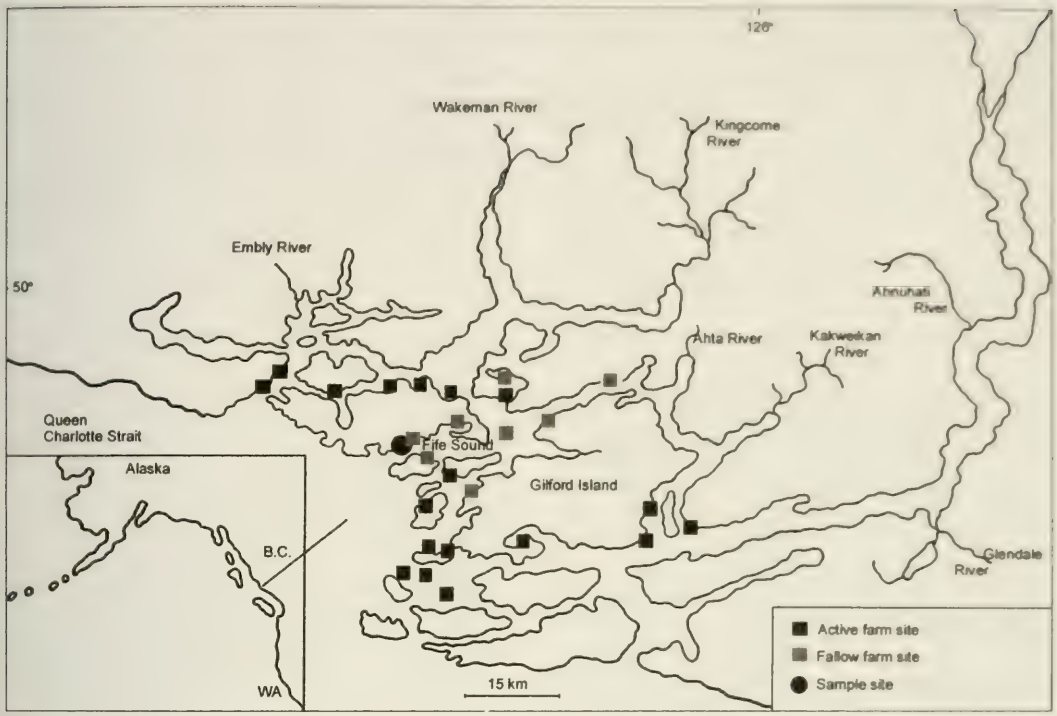

FIGURE 1. Study area, the Broughton Archipelago, showing major Pink Salmon rivers, salmon farm sites and status, and study site.

The adult salmon caught in this study were lifted from the water without a net and kept free from contact with any surface in order to reduce loss of lice. They were examined immediately for Sea Louse counts, stages and species identification using a hand lens. We estimated the infective capability of the returning adult salmon by counting gravid female sea lice per fish: a standard measure used to trigger de-lousing treatment of farm salmon to reduce infective capability and lower sea lice numbers on adjacent juvenile wild salmon (Heuch and Mo 2001).

Louse counts were not expected to follow a normal distribution. Rather than transforming the data, we made comparisons using Mann-Whitney U tests (MWU; the non-parametric equivalent of a two-sample t-test) in GraphPad version 3.05 by InStat (GraphPad Software Inc., 5575 Oberlin Drive, #110, San Diego, California 92121 USA).

We used the following standard measures of louse infestation rates (Margolis et al. 1982): prevalence = the proportion of fish infested with lice; intensity = the mean number of lice on each infected fish; and abundance = the mean number of lice on the entire sample.

Results

We fished for 47 "hook-hours" 4 June through July, without catching one adult Pink Salmon. We fished for 119 hook-hours in August until 19 September, and beginning on 4 August, caught 50 adult Pink Salmon at an average of 0.78 Pink Salmon/hook-hour (SE = 0.10, n = 17 fishing sessions, range 0-1.4 Pink Salmon/ hook-hour). Given that there was no variance in the 12 June/July fishing sessions (all 12 failed sessions to catch a fish), a Wilcoxon signed-rank test was conducted to assess whether the median catch-per-unit-effort in August and September differed significantly from the observed zero catch-per-unit-effort in June and July. The sum of positive ranks was 136, indicating that the median value was significantly greater than 0 ($P < 0.0001$).

Fisheries and Oceans Canada estimated that 188 730 Pink Salmon entered the Broughton Archipelago rivers from mid-August through September 2003 (G. McEachen, Fisheries and Oceans Canada, chief of conservation management for the central coast, Central Coast Area Office, 315-940 Alder Street, Campbell River, British Columbia V9W 2P8, personal commu-

TABLE 1. Mass, length, and sea lice infection of Pink and Chum salmon collected during the two sampling periods with average sea surface temperature and salinity for both time periods. "Total" signifies all *L. salmonis* and "cope" signifies copepodite *L. salmonis* only.

Period	n	Grams (SE)	Size cm (SE)	Salt % (SE)	Temp °C (SE)	Prevalence %		Abundance (SE) Range		Intensity (SE)	
						Total	Cope	Total	Cope	Total	Cope
June – July	623	6.94 (0.15)	8.47 (0.03)	29.1 (0.03)	12.1 (0.01)	43.0	7.2	1.20 (0.12) 0-42	0.079 (0.012) 0-2	2.79 (0.26)	1.09 (0.018)
August – 19 September	145	21.16 (0.57)	12.38 (0.10)	30.8 (0.11)	11.1 (0.05)	40.0	4.8	1.00 (0.25) 0-33	0.048 (0.018) 0-1	2.50 (0.58)	1 (0)

nication). This would indicate that Pink Salmon were present seaward of the rivers and within the study area for 2-3 weeks prior to the end of the second week of August, when they were first identified in the rivers, through September. We cannot be certain how many of these fish passed the sampling site, but Fife Sound is considered the primary migration corridor for adult Pink Salmon (Neidrauer, personal communication).

The tour operator and his guides looked for Pink Salmon on each of their tours, but did not see Pink Salmon in the largest Pink Salmon river in the study area, the Glendale River, until 20 August (H. Pattinson, owner/operator, Tide Rip Tours, 1660 Robb Avenue, Comox, British Columbia V9M 2W7 Canada, personal communication). Again, assuming that adults took two to three weeks to migrate through the Broughton Archipelago to reach the Glendale watershed, one would expect that the adults reached our sampling location in early August. In fact, these three methods show very good agreement, and all point to a best estimate return date for large numbers of wild adult Pink Salmon in the first days of August. Consequently, we estimate that juvenile Pink and Chum salmon were introduced to louse-infected adults around the first day of August.

We divided the pre- and post-exposure stages into two sampling periods: 1 June to 31 July, and 1 August to 19 September. As one would expect from a rapidly growing cohort, the juvenile salmon increased in both length and weight throughout the study (Table 1). The average seawater temperature and salinity varied slightly between the two sampling periods, but remained at all times within optimal range for *L. salmonis* (Table 1). The mean number of gravid lice on returning adult Pink Salmon was 9.31 (SE 0.93).

No measure of total Sea Louse occurrence varied between the sampling periods (Table 1) (abundance – MWU statistic: 43186, P = 0.4088; intensity – MWU statistic: 7153.5, P = 0.3412). As well, no measure of copepodite Sea Lice varied significantly (abundance – MWU 44072; P = 0.6448).

Given that there was no variance in the observed intensity of copepodid infection on juvenile salmon in the later sampling period (that is, all seven fish infected with copepodites carried a single copepodid louse), a Wilcoxon signed-rank test was used to assess whether the median early-season intensity differed from the observed intensity of 1 louse/fish in the later sampling season. The mean intensity of infection on the 45 fish infected with copepodites in the earlier sampling season was 1.09 (SE 0.043, median 1.00, range 1-2). This was not significantly greater than the 1 louse/infected fish observed in the later sampling season (sum of all signed ranks = 10, after correcting for ties; $P = 0.13$).

Discussion

The number of returning adult Pink Salmon carrying gravid Sea Lice was on the order of two hundred thousand, with approximately nine gravid Sea Lice per fish and thus we estimate that the juvenile Pink and Chum salmon in Fife Sound were exposed to the infective capability of close to two million gravid female Sea Lice. However no marked increase above the pre-existing background infection levels could be detected on juvenile salmon after the adult fish arrived in the area.

Even if the total number of Sea Lice failed to increase on juvenile salmon after the return of adult Pink Salmon, an increase in the proportion of lice at the copepodid stage would have indicated arrival of a source of Sea Lice that exceeded ambient levels. However, no increased copepodid settlement was observed. In fact, prevalence of copepodids was slightly lower after the adult Pink Salmon returned, which is as one would expect from an epizootic living out the course of its infestation. In the early, i.e., pre-exposure sampling period, 7.2% of juveniles sampled carried at least one copepodid, and after the adult Pink Salmon returned, 4.8% of juveniles sampled carried at least one copepodid. The juvenile salmon were traveling west out of an area where gravid Sea Lice occurred on farm salmon.

The decline we recorded in copepodite Sea Lice is contrary to what Krkosek et al. (2005) found where infected juvenile salmon re-infected each other as their farm-origin Sea Lice matured. The difference in

findings might be a result of geography. Krkosek et al. (2005) was conducted within the confined waterway of Tribune Channel, whereas this work occurred in an area of much greater flush at the archipelago edge. There are no juvenile Pink and Chum salmon in Tribune Channel in August. The juvenile Pacific salmon out-migrations and adult salmon in-migrations are generally timed such that interaction between the two cohorts occurs in open waters.

Ocean temperature and salinity were unlikely to have hindered parasite growth or transfer during August and September. Mean sea-surface temperature fell 1°C during the adult spawning in-migration, which had the potential to slow reproduction, but salinity increased, which favoured reproduction. Both values, however, were well within optimal range necessary for Sea Lice reproduction (Johnson and Albright 1991b; Boxaspen and Naess 2000; Tucker et al. 2000). Consequently, we conclude that the juvenile hosts in our study simply failed to respond measurably to exposure to a large influx of infested wild adult salmon.

We fully expected louse loads to increase when the adult Pink Salmon returned. We know that Sea Lice must be transmitted among wild salmon. The fact that Louse numbers did not increase in our study was surprising, and leads us to conclude that, compared to ambient levels of farm-origin parasitism in the Broughton Archipelago, the contribution of wild-source lice was negligible. We suspect the higher numbers of salmon-specific Sea Lice on juvenile Pink and Chum salmon in June and July originated from the population of several million, farmed Atlantic Salmon in the Broughton Archipelago in high-density open-net pens. Orr (*in press*) reports an average of several gravid sea lice per each of 6 million farm salmon during our study period, which translates into a very large number of copepodite sea lice occurring to the east of our study site area, but not at our study site itself which was adjacent to an empty salmon farm.

Why we did *not* find an increase in Sea Lice in August and September is perplexing. The mandatory 2-4 day dispersal term in the plankton layer likely limits Sea Louse recruitment rates to allow both parasite and host to thrive. Perhaps there were not enough wild adult Pink Salmon in the Broughton Archipelago for measurable Sea Lice transmission to the juvenile cohort in the face of such dispersal. Perhaps Sea Louse recruitment is an infrequent event between free-ranging salmon, and our sample size was too small to capture it. Perhaps the duration of exposure to adult Pink Salmon was not long enough or the dynamic of juvenile and adult salmon travelling in opposite directions with juveniles along the shoreline and adults mid-channel suppressed copepodid recruitment. Perhaps some small increase in parasite load did occur, but natural variability and small sample size left us with insufficient statistical power to detect this small effect above the ambient levels in the Broughton Archipelago. Morton et al. (2004) reported that in areas without salmon farms juvenile Pink Salmon were not infested with *L. salmonis*. Therefore, it is possible that in the absence of farm salmon the 4.8% prevalence we found on juvenile salmon in August and September could have been entirely or partially in response to arrival of the wild adult Pink Salmon.

Likely our inability to detect response in Sea Louse populations to returning adult Salmon was some combination of these. The lack of observed recruitment of new Sea Lice suggests that some mechanism has evolved to suppress transfer of lice from returning adults to out-migrating smolts in a naturally functioning ecosystem. Because Sea Louse pathogenicity is host-size dependant, protecting the smaller salmon from *L. salmonis* infestation would have clear evolutionary benefits, particularly for the Pink and Chum salmon that go to sea smaller than any other salmonid.

If exposure to abundant Sea Lice infested wild adults did not trigger a measurable increase in Sea Lice loads on juvenile Pink and Chum salmon, then this leaves the other, less abundant (if at all present), overwintering inshore wild salmon species poor candidates for explaining the enormous and recent spring *L. salmonis* outbreaks in the Broughton Archipelago.

Clearly, more extensive research is urgently needed. In the meantime, our study suggests that wild Pink Salmon do not appear to be the primary source of the high Sea Lice infestations reported on wild juvenile Pink and Chum salmon in the Broughton Archipelago. They may, however, be the primary source infecting the farm salmon and thus pose a risk to the industry. We conclude the most obvious source of *L. salmonis* on juvenile Pink and Chum salmon in the Broughton Archipelago is the stationary population of several million, farmed Atlantic Salmon.

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Physical Characteristics, Hematology, and Serum Chemistry of Free-ranging Gray Wolves, *Canis lupus*, in Southcentral Alaska

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Butler, Matthew J., Warren B. Ballard, and Heather A. Whitlaw. 2006. Physical characteristics, hematology, and serum chemistry of free-ranging Gray Wolves, *Canis lupus*, southcentral Alaska. Canadian Field-Naturalist 120(2): 205-212.

Examination of morphometric characteristics and blood parameters has become a widely used tool for assessing the physiological and nutritional status of wild and captive animals. During 1976 through 1984, 155 Gray Wolves (*Canis lupus*) were chemically immobilized in south-central Alaska. Of those, we obtained physical measurements from 132 and blood samples from 121 individuals. Also, 208 carcasses of harvested and dead radiocollared Wolves were weighed and measured. We obtained blood samples from three of the fresh carcasses. We measured age, body weight, skull length and width, and upper and lower canine length. We analyzed blood serum for Ca, P, Fe, chlorides, creatinine, glucose, lactic dehydrogenase, alkaline phosphatase, glutamic oxalic transaminase, triglyceride, beta globulin, serum urea nitrogen, and uric acid. We obtained packed cell volume and hemoglobin values from whole blood. We classified samples by season, sex, and age. Seasonal differences were observed for physical measurements, packed cell volume, alkaline phosphatase, and serum urea nitrogen. Age differences were observed for physical measurements, hemoglobin, packed cell volume, alkaline phosphatase, P, Ca, creatinine, serum urea nitrogen, and percent femur bone marrow fat. However, differences among sexes were observed for physical measurements only. These data provide a baseline for physical condition, hematology, and serum chemistry for free-ranging Gray Wolves.

Key Words: Gray Wolf, *Canis lupus*, blood, chemistry, hematology, measurements, physical, serum, Alaska.

Examination of morphometric characteristics and blood parameters has become a widely used tool for assessing the physiological and nutritional status of wild and captive animals (e.g., LeResche et al. 1974; Seal and Mech 1983; DelGiudice et al. 1987; Franzmann and Schwartz 1988). Although baseline hematology and serum chemistry values for many species of captive animals exist, baseline values for free-ranging animals are also necessary to properly interpret data. It is also important to understand how factors such as age, sex, and season influence hematology and serum chemistry values.

Hematology and serum chemistry of captive Gray Wolves (*Canis lupus*) has been studied and described by Fox and Andrews (1973) and Constable (1998) in Alaska, Seal and Mech (1983) and DelGiudice et al. (1987) in Minnesota, Pospíšil et al. (1987) in the Czech Republic, and Drag (1995) in Missouri. Seal et al. (1975) and DelGiudice et al. (1991) in Minnesota, Messier (1987) in Quebec, and Constable et al. (1998) in Alaska studied and described hematology and serum chemistry of free-ranging Gray Wolves. Mech et al. (1984) reported changes in hematology and serum chemistry of a female Gray Wolf recuperating from near starvation in Minnesota. However, little baseline data exist for age, sex, and season for free-ranging Gray Wolf populations. The purpose of our study was to describe physical characteristics and report baseline hematology and serum chemistry values for age, sex, and season in free-ranging Gray Wolves of south-central Alaska.

Study Area

The study was conducted in an area of approximately 45 000 km^2, known as Alaska Game Management Unit 13, located approximately 125 km northeast of Anchorage, Alaska. The area was bisected by three major river systems including the Copper, Nelchina, and Susitna rivers. Primary prey species were Moose (*Alces alces*) and Barren-ground Caribou (*Rangifer tarandus granti*). Alternate prey species included Dall Sheep (*Ovis dalli*), Beaver (*Castor canadensis*), and Snowshoe Hare (*Lepus americanus*). Climate, topography, and other important aspects of the study area were described by Ballard et al. (1987, 1991b). Gray Wolf densities during this study ranged from 10.3/1000 km^2 in autumn 1975 to 2.6/1000 km^2 in spring 1982 (Ballard et al. 1987). Mean annual litter size in November ranged from 3.7 to 7.3 pups. The Wolf population was heavily exploited by humans (i.e., >40% of population) during the course of this study (Ballard et al. 1987).

The reference values we present here occurred during a period when both Moose and Caribou populations were increasing. Moose densities were highly variable in the study area and averaged about 603 to 741/1000 km^2 (Ballard et al. 1991b) and the population increased at a finite rate of increase of 1.03 to 1.06 annually (Ballard et al. 1986). Caribou populations during this time period increased from approximately 10 000 in 1976 to about 25 000 in 1984 (Bergerud and Ballard 1988). Winter conditions as reflected by snow depths were relatively moderate during this

time period except during 1978-1979 which was classified as severe (Ballard et al. 1991b).

Methods

We captured Gray Wolves for radiocollaring by darting them from a helicopter during 1976 through 1984 using methods described by Ballard et al. (1982, 1991a). We immobilized Wolves with phencyclidine hydrochloride, etorphine hydrochloride, or a combination of zolzepam hydrochloride and tiletamine hydrochloride following dosages and methods described by Ballard et al. (1982, 1991a). Induction times averaged 7.2 minutes (Ballard et al. 1991a). After immobilization each Wolf was radiocollared, weighed, sexed, eartagged, bled, and a number of physical measurements were recorded on standardized forms. Physical measurements included skull length (SL) and width (SW), and upper (UCL) and lower canine length (LCL). We measured canine length from the edge of the gum line to the tip of the tooth. Skull and tooth measurements were taken with calipers and recorded to the nearest mm.

Hunters and trappers were paid $10 (U.S.) per skinned Wolf carcass. Carcasses were weighed (CW) and then kept frozen until examined. Skulls were not boiled and cleaned before measuring to maintain similarity with live Wolf measurements. Also, the effects of freezing carcasses on physical measurements were likely minimal. We determined percent femur bone marrow fat (MF) by the dry weight method (Neiland 1970). Because this Wolf population was heavily exploited (Ballard et al. 1987) we were able to do comparisons with many individuals that had been radiocollared and harvested within the same year.

We collected blood samples from saphenous veins using the B-D Vacutainer system (Becton-Dickenson Co., Rutherford, New Jersey, USA). Generally blood was taken within 15 minutes of induction time and serum was separated each evening. Only three blood samples were collected from carcasses. Those samples were obtained within 15 minutes of harvest. We used one EDTA tube to preserve whole blood. Packed cell volume (PCV) was determined with uncoagulated whole blood using a microhematocrit centrifuge (Triac, Clay-Adams Co., Parisppany, New Jersey, USA) while hemoglobin (Hb) was estimated with an AO Hb-Meter (American Optical, Buffalo, New York, USA). Clotted blood was centrifuged within 36 h of collection and serum was then stored frozen at -17°C. We sent frozen serum to Pathologist Central Laboratory, Seattle, Washington, USA, where it was analyzed for the following via an auto-analyzer: calcium (Ca), phosphorous (P), iron (Fe), chlorides (CHL), creatinine (CRE), glucose (GLU), lactic dehydrogenase (LDH), alkaline phosphatase (SAP), glutamic oxalic transaminase (SGOT), triglyceride (TRI), serum urea nitrogen (SUN), and uric acid (UA). Protein fractions were determined by standard protein electrophoresis for beta globulin (BEG).

Because of unbalanced cells in our analyses, we pooled years, sorted blood and physical measurements by sex, age, and season, and conducted multiple analyses of variance. We conducted post-hoc comparisons with a Scheffe test (Sokal and Rohlf 1995). We determined correlations among variables by Spearman's rank correlation (Conover 1980). We classified ages as pup (≤12 months), yearling (13 to 23 months), and adult (≥24 months), while seasons were divided into autumn (September through November), winter (December through February), spring (March through May), and summer (June through August). Differences were considered significant when $P < 0.05$ unless otherwise specified.

Results

We immobilized 155 individual Gray Wolves during 1976 through 1984. From that total, we obtained 121 blood samples ($n = 121$ serum samples, $n = 117$ whole blood samples) and 132 live body weights (BW). Due to low sample sizes, we excluded yearling and summer data from the analyses. In addition, we weighed and measured a total of 208 carcasses. We obtained three blood samples from fresh carcasses ($n = 3$ serum samples, $n = 2$ whole blood samples).

Physical Characteristics

Mean BW differed by season ($F = 26.121$, 2 df, $P < 0.001$), sex ($F = 37.084$, 1 df, $P < 0.001$), and age ($F = 147.890$, 1 df, $P < 0.001$), and there were significant interactions between season and age ($F = 15.665$, 2 df, $P < 0.001$), and among season, sex, and age ($F = 3.231$, 2 df, $P = 0.043$). Lowest BW occurred for pups during autumn, while highest BW occurred for adult males during autumn and winter (Table 1). Adult males had higher BW than male pups during autumn and winter; adult females had higher BW than female pups during autumn and spring (Table 1). Body weights were not different between adult males and adult females among seasons (Table 1). Body weights between male and female pups was only significantly different during spring (i.e., males were heavier; Table 1). Body weights of male pups increased with seasons (i.e., over the course of the biological year); both winter and spring BW were higher than autumn weights, although winter and spring were not different (Table 1). In addition, BW of female pups increased with season though female pups were significantly heavier in the spring than during autumn (Table 1).

Mean CW exhibited similar trends by sex, age, and season as BW although sample sizes were too small to evaluate post-hoc differences (Table 1). Season ($F = 4.849$, 2 df, $P = 0.009$), sex ($F = 6.665$, 1 df, $P = 0.011$), and age ($F = 24.849$, 1 df, $P < 0.001$) each had a significant effect on CW and there were significant interactions between sex and age ($F = 3.950$, 2 df, $P = 0.046$), and among season, sex, and age

TABLE 1. Mean physical measurements ± 1 standard error by season, sex, and age for free-ranging Gray Wolves in south-central Alaska during 1976 through 1984. Sample size denoted in parentheses.

Physical measurements	Age	Sex	Season		
			Autumn	Winter	Spring
Live-body weight (kg)	Pup	Male	26.2 ± 2.3 (8)	37.9 ± 1.4 (10)	41.3 ± 1.4 (16)
		Female	23.5 ± 2.0 (7)	33.3 ± 2.5 (5)	33.3 ± 0.9 (20)
	Adult	Male	46.8 ± 1.5 (8)	48.1 ± 1.3 (11)	46.2 ± 0.9 (17)
		Female	38.9 ± 1.4 (13)	41.1 ± 1.2 (3)	42.4 ± 1.0 (14)
Carcass weight (kg)	Pup	Male	19.7 ± 2.7 (3)	30.7 ± 0.9 (51)	29.9 ± 2.5 (8)
		Female	25.0 ± 2.4 (3)	27.3 ± 0.6 (51)	25.3 ± 1.0 (7)
	Adult	Male	39.1 (1)	39.8 ± 0.9 (36)	33.5 ± 1.8 (8)
		Female	24.8 ±13.8 (2)	32.8 ± 0.7 (32)	33.8 ± 1.1 (6)
Skull length (cm)	Pup	Male	24.5 ± 0.8 (3)	26.2 ± 0.2 (58)	27.1 ± 0.3 (18)
		Female	24.5 ± 0.7 (5)	25.1 ± 0.2 (52)	25.5 ± 0.3 (14)
	Adult	Male	27.7 ± 0.3 (3)	27.8 ± 0.2 (39)	27.0 ± 0.4 (12)
		Female	24.8 ± 1.0 (3)	26.5 ± 0.2 (31)	26.4 ± 0.4 (12)
Skull width (cm)	Pup	Male	12.3 ± 0.5 (3)	13.5 ± 0.1 (58)	14.4 ± 0.2 (18)
		Female	12.4 ± 0.4 (5)	13.1 ± 0.2 (52)	14.0 ± 0.7 (14)
	Adult	Male	16.0 ± 0.6 (3)	14.8 ± 0.1 (35)	14.9 ± 0.3 (12)
		Female	13.4 ± 0.5 (6)	14.5 ± 0.3 (30)	14.3 ± 0.1 (11)
Upper canine length (cm)	Pup	Male	2.1 ± 0.2 (2)	2.5 ± 0.1 (38)	2.6 ± 0.1 (11)
		Female	1.9 ± 0.1 (5)	2.3 ± 0.1 (45)	2.3 ± 0.1 (10)
	Adult	Male	2.8 ± 0.04 (6)	2.9 ± 0.1 (32)	3.0 ± 0.1 (7)
		Female	2.3 ± 0.3 (3)	2.5 ± 0.1 (25)	2.5 ± 0.04 (6)

($F = 4.105$, 1 df, $P = 0.018$). Lowest CW occurred for pups during autumn, while highest weights were for adult males during autumn and winter (Table 1).

There were significant differences in average SL by season ($F = 5.008$, 2 df , $P = 0.007$), sex ($F = 23.574$, 1 df , $P < 0.001$), and age ($F = 22.331$, 1 df , $P < 0.001$), and there were significant interactions between season and age ($F = 3.769$, 2 df , $P = 0.024$) and among season, sex, and age ($F = 3.874$, 2 df , $P = 0.022$). Lowest mean SL was for pups during autumn and highest mean SL was for adult males during autumn and winter (Table 1). Males had higher mean SL than females during each season (Table 1). Mean pup SL increased from autumn through spring (Table 1).

Mean SW differed by season ($F = 3.831$, 2 df , $P = 0.023$), sex ($F = 7.692$, 1 df , $P = 0.006$), and age ($F = 32.160$, 1 df , $P < 0.001$), and there was a significant interaction between season and age ($F = 4.582$, 2 df , $P = 0.011$). Mean male SW was greater than female SW for all seasons and ages (Table 1). There were no differences in average adult SW among seasons (Table 1). Also, mean pup SW increased by season during the first year of life (Table 1).

Mean UCL differed by season ($F = 5.257$, 2 df , $P = 0.006$), sex ($F = 19.804$, 1 df , $P < 0.001$), and age ($F = 26.872$, 1 df , $P < 0.001$), and there were no significant interactions. Mean UCL was lower during autumn than during either winter or spring (Table 1). Mean male UCL was greater than that of females (Table 1). Mean UCL for adults was greater than that for pups (Table 1). There was no significant difference in mean LCL by season ($F = 0.002$, 1 df , $P = 0.964$), sex ($F = 1.707$, 1 df , $P = 0.218$), or age ($F = 0.828$, 1 df , $P = 0.382$), and there were no significant interactions. Mean LCL was 2.3 ± 0.07 cm ($n = 18$). Body weight was also correlated with the other physical characteristics, MF, and PCV (Table 2).

Hematology

Mean Hb concentration differed by age ($F = 7.671$, 1 df , $P = 0.007$) and there was a significant interaction between age and season ($F = 3.876$, 2 df , $P = 0.024$); differences were between pups and adults during winter and autumn (Table 3). Mean pup Hb concentrations increased throughout the year, whereas adult Hb concentrations remained relatively constant during the year (Table 3).

Average PCV differed by season ($F = 6.015$, 2 df, $P = 0.003$) and age ($F = 29.083$, 1 df, $P < 0.001$), and there was a significant interaction between season and age ($F = 10.375$, 1 df, $P < 0.001$). Adults during autumn had higher mean PCV than all other groups by season and age (Table 3). Mean PCV did not differ between adults and pups in winter and spring (Table 3). Packed cell volume was also correlated with Hb and BW (Table 2).

Serum Chemistry

Mean SAP concentration differed by season ($F = 6.557$, 2 df, $P = 0.002$) and age ($F = 19.621$, 1 df, $P < 0.001$), and there was a significant interaction between age and season ($F = 5.189$, 2 df, $P = 0.007$). Mean SAP concentration appeared greater in pups than adults during autumn, winter, and spring (Table 3). However, only during autumn were SAP concentrations significantly different between pups and adults (Table 3). Among pups, autumn and winter SAP concentrations were higher than spring, but only the autumn–spring comparison was significant. Among adults, seasonal

TABLE 2. Correlations among physical characteristics, hematology, and serum chemistry values for free-ranging Gray Wolves in south-central Alaska during 1976 through 1984.

	Characteristics	r_s	n	P
Body weight	Carcass weight	0.954	23	<0.001
	Skull length	0.665	67	<0.001
	Skull width	0.639	62	<0.001
	Upper canine length	0.583	47	<0.001
	Marrow fat	0.725	14	0.003
	Packed cell volume	0.271	97	0.007
	Hemoglobin	0.362	82	0.001
Marrow fat	Carcass weight	0.365	108	<0.001
	Skull length	0.281	108	0.003
	Skull width	0.494	108	<0.001
	Upper canine length	0.316	79	0.005
Serum alkaline phosphatase	Age	–0.516	91	<0.001
	Phosphorous	0.600	140	<0.001
	Calcium	0.511	142	<0.001
Beta globulin	Lactic dehydrogenase	0.500	91	<0.001
Packed cell volume	Hemoglobin	0.527	102	<0.001

TABLE 3. Mean blood characteristics ± 1 standard error by season and age for free-ranging Gray Wolves in south-central Alaska during 1976 through 1984. Sample size denoted in parentheses.

Blood characteristics	Age	Season Autumn	Winter	Spring
Alkaline phosphatase (IU/L)	Pup	177.8 ± 33.1 (10)	141.9 ± 32.0 (15)	65.0 ± 6.9 (29)
	Adult	49.3 ± 6.1 (21)	90.0 ± 38.8 (12)	49.8 ± 6.7 (37)
Urea nitrogen (mg/dL)	Pup	26.2 ± 2.5 (10)	25.4 ± 6.0 (15)	46.1 ± 4.1 (29)
	Adult	45.4 ± 4.2 (21)	37.6 ± 7.4 (12)	52.9 ± 3.4 (37)
Hemoglobin (g/dL)	Pup	17.9 ± 0.4 (8)	18.0 ± 0.8 (10)	19.1 ± 0.2 (26)
	Adult	19.9 ± 0.07 (21)	18.9 ± 0.6 (11)	19.0 ± 0.3 (29)
Packed cell volume (%)	Pup	47.8 ± 2.2 (7)	44.2 ± 1.2 (12)	49.0 ± 1.1 (32)
	Adult	63.6 ± 2.0 (23)	55.1 ± 1.8 (11)	49.7 ± 1.3 (34)

SAP concentrations were not significantly different (Table 3). Serum alkaline phosphatase was also correlated to age, P, and Ca (Table 2).

Mean SUN concentration differed by season ($F = 6.746$, 2 df, $P = 0.002$) and age ($F = 10.382$, 1 df, $P = 0.002$), and there were no significant interactions. Mean SUN concentration was higher during spring than in winter; autumn SUN concentration was not different from spring or winter (Table 3). Mean adult SUN concentration was higher than that of pups, regardless of season or sex (Table 3).

Mean P ($F = 6.595$, 1 df, $P = 0.012$), Ca ($F = 6.036$, 1 df, $P = 0.016$), and CRE ($F = 4.189$, 1 df, $P = 0.043$) concentrations differed by age with no significant interactions. Pup P concentrations were higher than adults, regardless of season or sex, as were Ca concentrations (Table 4). Mean adult CRE concentration was higher than that of pups, regardless of season or sex (Table 4). There were no significant differences in mean values of BEG, CHL, GLU, Fe, LDH, SGOT, TRI, or UA by season, sex, or age, and there were no significant interactions (Table 5). Measures of BEG were also correlated with LDH concentrations (Table 2).

Bone Marrow Fat

Mean MF differed by age ($F = 5.062$, 1 df, $P = 0.027$). Mean pup MF was less than adult MF (Table 4). There were no differences in mean MF by season ($F = 0.351$, 1 df, $P = 0.555$) or sex ($F = 0.000$, 1 df, $P = 0.989$) and there were no significant interactions. Percent bone marrow fat was also correlated to BW, CW, SL, SW, and UCL (Table 2).

Discussion

Average BW of free-ranging Gray Wolves in south-central Alaska was greater than captive Gray Wolves in Minnesota (VanBallenberghe and Mech 1975; Seal and Mech 1983; Mech 2006) probably reflecting subspecies differences (Mech 1970). The relationship between CW and BW may allow managers to gain reliable biological data from harvested individuals. Also, the relationship between BW and MF may allow biologists to infer condition based upon BW.

Pup and adult Hb concentrations were in the upper range of values reported for free-ranging (Seal et al. 1975; Messier 1987; DelGiudice et al. 1991) and captive (Seal and Mech 1983; DelGiudice et al. 1987;

Pospíšil et al. 1987) Gray Wolves. In addition, we observed a correlation between Hb and BW and it has been suggested Hb concentration is a good indicator of physical condition (Franzmann and LeResche 1978; Messier 1987; Franzmann and Schwartz 1988). However, Harlow and Seal (1981) observed little change in Hb concentrations in food-deprived captive Badgers (*Taxidea taxus*). Perhaps, lower Hb concentrations in pups are indicative of a dietary difference due to social status. Seal and Mech (1983) observed low Hb concentrations during July and August in captive Gray Wolves. They also noted reduced BW during this period. Also, lower Hb concentrations in winter than in spring were reported by Thomas and Kittrell (1966) for German shepherds. Changes in Hb concentrations by season have also been observed in female Black Bears (*Ursus americanus*) (Franzmann and Schwartz 1988) and female White-tailed Deer (*Odocoileus virginianus*) (DelGiudice et al. 1992). However, our Hb data were unaffected by season and we observed comparable Hb concentrations in summer (18.6 ± 1.4 g/dL, $n = 5$). Franzmann and LeResche (1978) did not observe a seasonal effect on Hb concentrations in Moose. Perhaps, the reduced BW and Hb concentrations observed by Seal and Mech (1983) during summer can be attributed to a physiological response to greater summer heat in Minnesota. However, the elevation of Alaska Game Management Unit 13 lies above 1,220 m and the research conducted by Thomas and Kittrell (1966) suggested increased elevation resulted in increased Hb concentrations in German shepherds. Thus, perhaps, high Hb concentrations in south-central Alaskan Gray Wolves may have been due to higher elevation.

Thomas and Kittrell (1966) also observed increased elevation resulted in increased PCV levels in German shepherds. Perhaps, this explains why mean PCV in south-central Alaskan Wolves was greater than values reported by DelGiudice et al. (1991) in free-ranging Minnesota Wolves. Similar PCV values have been observed in free-ranging (Smith and Rongstad 1980) and captive (Gates and Goering 1976; Rich and Gates 1979) Coyotes (*Canis latrans*).

Franzmann and LeResche (1978) and Franzmann and Schwartz (1988) suggested PCV was a good indicator of physical condition. We also observed a seasonal effect on PCV. Autumn PCV (59.9 ± 2.0%, $n = 30$) was greater than spring (49.4 ± 0.8%, $n = 66$) and winter (49.4 ± 1.6%, $n = 23$). This suggests Wolves in Alaska Game Management Unit 13 were in their best physical condition in autumn. However, different seasonal patterns were observed by Thomas and Kittrell (1966) in German shepherds: lower PCV in winter than spring. Seasonal changes in PCV have also been observed in female Black Bears (Franzmann and Schwartz 1988), female White-tailed Deer (Bahnak et al. 1979; DelGiudice et al. 1992), and Moose (Franzmann and LeResche 1978). Female White-tailed Deer in Minnesota exhibited two peaks (February-March and October-November) in BW and PCV (DelGiudice et al. 1992). However, PCV levels in Michigan female White-tailed Deer reached their lowest levels in July through September when those animals reached slightly lower weights (Buhnak et al. 1979). Female Black Bear exhibited a decline in PCV during summer and, though not significant, an increase during autumn (Franzmann and Schwartz 1988). Franzmann and LeResche (1978) observed greater PCV during June through October in Moose.

TABLE 4. Mean characteristics ± 1 standard error by age for free-ranging Gray Wolves in south-central Alaska during 1976 through 1984. Sample size denoted in parentheses.

Characteristics	Age	Mean ± standard error (n)
Phosphorous (mg/dL)	Pup	5.8 ± 0.3 (54)
	Adult	4.4 ± 0.4 (69)
Calcium (mg/dL)	Pup	9.6 ± 0.3 (54)
	Adult	8.9 ± 0.3 (70)
Creatinine (mg/dL)	Pup	0.9 ± 0.04 (54)
	Adult	1.1 ± 0.1 (70)
Marrow fat (%)	Pup	79.6 ± 16.9 (64)
	Adult	87.0 ± 9.2 (44)

TABLE 5. Mean serum chemistry values ± 1 standard error for free-ranging Gray Wolves (season, sex, and age combined) in south-central Alaska during 1976 through 1984. Sample size denoted in parentheses.

Serum chemistry values	Mean ± standard error (n)
Iron (umol/L)	47.4 ± 4.5 (71)
Chlorides (mmol/L)	161.1 ± 4.0 (124)
Glucose (mg/dL)	118.7 ± 7.4 (122)
Lactic dehydrogenase (IU/L)	306.7 ± 22.7 (123)
Glutamic oxalic transaminase (IU/L)	226.5 ± 23.8 (120)
Triglyceride (mg/dL)	51.8 ± 5.8 (124)
Beta gobulin (g/dL)	1.0 ± 0.06 (93)
Uric acid (mg/dL)	1.3 ± 0.09(114)

Our SUN data was greater than or in the upper range of values reported for free-ranging Wolves (Seal et al. 1975; Messier 1987), captive Wolves (Seal and Mech 1983; Drag 1995), captive Coyotes (Rich and Gates 1979; Dunbar and Giordano 2002), and free-ranging Coyotes (Smith and Rongstad 1980). However, other studies have reported concentrations similar to this study. DelGiudice et al. (1987) reported average SUN concentrations of well-fed captive Gray Wolves between 37.5 and 44.4 mg/dL. However, during fasting those concentrations were reduced to a range of 12.0 to 19.8 mg/dL. Another study conducted on free-ranging Wolves ($n = 11$) in the Yukon-Charley Rivers National Preserve, Alaska (Constable et al. 1998), reported SUN concentrations (46.2 mg/dL) similar to our observations.

Higher dietary intake of protein is indicated by higher SUN concentrations as described for Dogs (Lane

and Robinson 1970; Bressani and Braham 1977), White-tailed Deer (Seal et al. 1972; Bahnak et al. 1979), and Pronghorn (*Antilocapra americana*) (Seal and Hoskinson 1978). We observed lower SUN concentrations in pups, suggesting a dietary difference, perhaps, due to social status. We also observed seasonal differences in SUN concentrations. Urea nitrogen was greatest during spring, intermediate in autumn, and lowest in winter, suggesting greatest intake of protein during spring. This may be indicative of increased Moose vulnerability due to reduced Moose group size and increased number of calves (Ballard et al. 1991b). Though sample size was low ($n = 5$), SUN concentration during summer was relatively high (41.8 + 6.1 mg/dL) which was comparable to well-fed captive Wolves (DelGiudice et al. 1987). Seasonal variation has also been observed in Black Bears (Franzmann and Schwartz 1988), female White-tailed Deer (Bahnak et al. 1979; DelGiudice et al. 1992), Santa Cruz Island Spotted Skunks (*Spilogale gracilis amphiala*) (Crooks et al. 2003), Santa Cruz Island Foxes (*Urocyon littoralis*) (Crooks et al. 2000), and Son Joaquin Kit Foxes (*Vulpes macrotis mutica*) (McCue and O'Farrell 1992). For each of these species, peak SUN concentrations appeared to coincide with the most productive seasons.

Phosphorus concentrations were similar to those reported for free-ranging (Seal et al. 1975; Messier 1987; Constable et al. 1998) and captive (Drag 1995; Constable et al. 1998) Wolves. Our analyses suggested pup P concentrations were higher than adults. Messier (1987) observed lower P concentrations in adults as well. Calcium concentrations were similar to reported values (DelGiudice et al. 1987 in addition to those cited above). However, no other Wolf study reported pup Ca values but we observed pup Ca concentrations were higher than adults. We also observed higher SAP concentrations in pups than adults. This has been observed in Gray Wolves (Messier 1987), Coyotes (Smith and Rongstad 1980), and Dogs (Pickrell et al. 1974). High SAP concentration is indicative of bone formation and osteoblast differentiation (Searcy 1969). Serum alkaline phosphatase was also correlated to age, P, and Ca. Interestingly, of adult SAP values, 11.4% (all male and sampled in different seasons) were above the lower 95% confidence interval for pup SAP values. High SAP concentration has been associated with mammary tumors in dogs (Karayannopoulou et al. 2003), mast cell disease in humans (Pardanani et al. 2002), pregnancy in animals (Stockham and Scott 2002; Bain 2003), healing of broken bones (Searcy 1969), and other diseases in Dogs (Cornelius 1980). Thus, SAP concentration may be used to identify injured or diseased individuals.

Conclusions

New patterns in physical condition, hematology, and serum chemistry were identified for Gray Wolves. Pups appeared to be under greater nutritional stress than adults as suggested by reduced MF, PCV, and SUN and Hb concentrations in pups. We also confirmed established differences in SAP concentrations between adults and pups. However, abnormally high SAP concentrations were observed in a portion of the adult male Wolves, perhaps, identifying injured or diseased individuals. High PCV in autumn suggested Gray Wolves of this population were in their best physical condition during autumn. High SUN concentrations in spring suggested these Wolves were under little nutritional stress during spring and appeared to be on a good nutritional plane during summer, as suggested by relatively high summer SUN concentrations. Also, high Hb concentrations and PCV in this population were probably a result of higher elevation.

These data, classified by season, sex, and age, provide a baseline physical condition, hematology, and serum chemistry for free-ranging Gray Wolves with a relatively high and increasing prey base in south-central Alaska. However, more information on yearlings and summer is needed to properly understand physical condition, hematology, and serum chemistry of this Gray Wolf population. Although we found several correlations among BW, Hb, PCV, MF, and several other variables, a number of measurements should be used to assess physical condition.

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Are Lesser Snow Geese, *Chen caerulescens caerulescens*, Exceeding the Carrying Capacity of the Fraser River Delta's Brackish Marshes?

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Brackish marshes of the Fraser River delta provide important habitats for such high-profile animals as White Sturgeon (*Acipenser transmontanus*), Pacific Eulachon (*Thaleichthys pacificus*), Pacific salmon (*Oncorhynchus* spp.), Western Sandpiper (*Calidris mauri*), and Lesser Snow Goose (*Chen caerulescens caerulescens*), the latter comprising the "Fraser Skagit" segment of the Wrangel Island (Russia) population. This study assessed whether the current numbers of Snow Geese are exceeding the carrying capacity of brackish marshes in the Fraser River delta. Simulation modelling predicts that those marshes are presently capable of supporting ~17 500 Snow Geese—a value that is greatly exceeded by the numbers of geese that have over-wintered there in recent years (~80 000 in 2004-2005). The Pacific Flyway Council's target 3-y average population and segment sizes of 120 000 and 50 000 - 70 000, respectively, were set without considering the carrying capacity of natural wintering habitats, the potential impacts of too many geese on upland agriculture, or implications for hazards to civilian aircraft at Vancouver International Airport. The modelled results of the present study suggest that the Fraser River delta can sustain the current numbers of Snow Geese that stage or winter there only if those birds also forage in agricultural and refuge fields—a relatively recent phenomenon that likely bolstered the Snow Goose population. Over-use by Snow Geese can degrade the productivity and habitat quality of marshes. There is documented evidence that some key plant species (e.g., *Scirpus americanus*) of the brackish marshes of the Fraser River delta are well below their biomass potential (~15%), primarily because of grubbing by Snow Geese. Other species that depend on this brackish environment as well as human interests in the Fraser River delta may be adversely affected by an overabundance of Snow Geese. The future effectiveness of hunting as a primary means of population regulation is questioned.

Key Words: Lesser Snow Goose, *Chen caerulescens caerulescens*, American Three-square Bulrush, *Scirpus americanus*, brackish marsh, carrying capacity, Fraser River delta, bird strike, British Columbia.

The recent dramatic increase in numbers of the mid-continent (North America) Lesser Snow Goose (*Chen caerulescens caerulescens*) has attracted considerable attention—mainly because of the habitat degradation it has caused (e.g., Kerbes et al. 1990; Williams et al. 1993; Ankney 1996). Consumption of agricultural foods (which may be more abundant and contain higher fractions of metabolizable energy than native brackish-marsh plants) and a network of refugia are thought to have contributed to substantial increases in some North American populations of Lesser Snow Geese by improving overwinter survival (Ankney 1996; Jefferies 1997). Although the bird community that winters on the Fraser River delta contains many species of grazing waterfowl, the large amount of rhizome biomass consumed annually by Lesser Snow Goose (Boyd 1995) means it is potentially a keystone species there as it is elsewhere (e.g., Kerbes et al. 1990).

Many Snow Geese that breed on Wrangel Island (Russia) use the Fraser River delta as staging or wintering habitat between October and April (Subcommittee on White Geese 1992*; Boyd 1995; Pacific Flyway Council 2006*). They forage in brackish marshes of the Fraser River delta, primarily on rhizomes of American Three-square Bulrush (*Scirpus americanus*) and shoots of Lyngbei Sedge (*Carex lyngbyei*). J. P. Hatfield (personal communication, cited in Campbell et al. 1990) noted that Snow Geese began foraging in agricultural fields on the Fraser River delta in 1977. The number of Snow Geese using those fields rose from 2000 in the early 1980s to between 20 000 and 30 000 in the 1990s (Boyd 1995; Canadian Wildlife Service et al. 1999*). The Canadian Wildlife Service (CWS) and local farmers actively enhance the Alaksen National Wildlife Area (ANWA) on Westham and Reifel islands in the Fraser River delta for wintering Snow Geese and other waterfowl. Fields within the ANWA are planted with crops to provide the birds with supplemental feed (Pacific Flyway Council 2006*).

Because Snow Geese and other grazing waterfowl can affect private agricultural fields outside the ANWA by consuming grass, crops, or crop residue such as corn and potatoes, and by altering surface-water drainage, the "Greenfields Program" administered by the Delta Farmland and Wildlife Trust (DFWT) was established in 1990. The goal of that program is to spread waterfowl impacts over a larger area, thereby lessening their severity in any one given area (Smith 1996*). The program encourages farmers to plant cover crops for soil conservation and provide forage for over-win-

tering waterfowl. The costs of these cropping practices are shared among farmers, conservation societies, and government bodies.

Snow Geese that overwinter on the Fraser River delta are managed according to the Pacific Flyway Council's 2006 management plan (Pacific Flyway Council 2006*) which is a revised version of the 1992 plan (Subcommittee on White Geese 1992*). Although the overall Wrangel Island population target of 120 000 birds (3-year average) remains the same between the 1992 and 2006 plans, the target size of the Fraser-Skagit segment (also referred to as "subpopulation" or "flock") target was increased to a range of 50 000-70 000 birds in the 2006 plan. According to the 1992 plan, the segment target was a minimum 3-year average of 35 000 birds. To achieve that, the ideal segment size had been identified to be between 30 000 and 60 000 birds (S. Boyd, personal communication). The historical size of the Wrangel Island population was considered when the goal was set, but some key factors were not: the carrying capacity of the Fraser and Skagit deltas, the possible impacts of Snow Geese on habitat quality and ecosystem function of the Fraser River delta, nor the possible impacts of Snow Geese on agriculture or air-safety. Under the 2006 plan, regulation of the Wrangel Island population is to occur by way of sport and subsistence hunting.

Burton (1977) concluded 30 years ago that the brackish marshes of the Fraser River delta would be damaged if the Fraser-Skagit segment exceeded 20 000 Snow Geese. The purpose of this study was to evaluate, by way of simulation modelling, recent numbers of Snow Geese in light of the carrying capacity of the brackish marshes in the Fraser River delta.

Study Area

The Fraser River sustains the largest delta on Canada's Pacific coast. The delta covers ~680 km^2 of aquatic and terrestrial areas, stretching 30 km from New Westminster westward to Sand Heads Lighthouse and from Point Grey southward to the international boundary (Butler and Campbell 1987). Brackish marshes occupy ~3% of the delta.

The Fraser River delta is a critical link in a series of migratory bird habitats along the Pacific Flyway between the arctic breeding grounds of North America and northeast Asia and wintering areas in southwestern North America, Central America, and South America. The delta supports some of the highest densities of wintering waterfowl, shorebirds, and raptors in Canada (Butler and Campbell 1987).

Brackish marshes of the Fraser River delta have evolved as a result of the interactions between the maritime conditions of the Pacific Ocean and the fresh water and sediment load of the Fraser River (Hutchinson 1982). Local tides are predominantly semidiurnal with a maximum range of ~5 m. The Fraser River is the largest river in British Columbia, with a mean annual flow of 3500 m^3/s. Eighty percent of the annual flow occurs during March to July (Hoos and Packman 1974, *cited in* Hutchinson 1982). Hutchinson (1982) divided the present brackish marshes of Lulu Island into three elevational zones: (1) low marsh—dominated by *Scirpus americanus* and *S. maritimus*; (2) middle marsh—dominated by *Carex lyngbyei*, *Triglochin maritimum*, and *S. maritimus*; and (3) high marsh—a community of *Agrostis exerata*, *Potentilla pacifica*, *Distichlis spicata*, and *Typha latifolia*.

Prior to dyking, the low elevations of much of the land near the western limit of the delta were subject to periodic flooding during spring freshet. Such flooding would have affected the delta's vegetation communities. Habitats of this area have been, and are heavily, modified by human activities. Although much of the Fraser River delta is used for agriculture, residential, commercial, and industrial developments are rapidly increasing at the expense of agricultural land-uses. Commercial greenhouse operations are increasingly replacing traditional field-based agriculture.

Much of the upland and foreshore areas of Reifel Island and Westham Island make up a wildlife sanctuary that is managed by the CWS. The sanctuary comprises 586 ha, of which 300 ha includes the federally owned ANWA that was designated a Ramsar site in May 1982 (Wetlands International, no date*). Approximately 410 ha of the sanctuary are in cultivated farmland. The adjacent George C. Reifel Refuge, initiated in the 1960s, consists of 400 ha of Crown land designated as a Migratory Bird Sanctuary under the Migratory Birds Convention Act of 1917.

Nearly 6000 ha in the municipality of Delta is used to produce vegetable crops and livestock. Of the cropland, nearly two-thirds is planted in vegetables such as potatoes, peas, beans, corn, pumpkins, cabbage, rutabagas. Hay fields, pasture, and corn silage represent more than one-quarter of the cropland on the delta. The remainder of the cropland on the delta is allocated to cereals and berries.

Methods

A map of the brackish marshes was prepared by digitally scanning colour air photos (1:24 000 scale) at high resolution and ortho-rectifying each photo by tying control points to those on a TRIM base-map (1:20 000 scale). Air photos from 18 September 1991 were deemed the best in terms of resolution, scale, date, season, and tide height. I. Hutchinson (personal communication) indicated that the brackish marsh profile has likely undergone very minor net changes since that time. Habitat polygons were digitized manually on-screen while viewing habitat features at various magnifications. The digital map upon which habitat calculations were made had a minimum resolution of 1:10 000. Small patches of *Scirpus* spp. near southwestern Sea Island were amalgamated because it was believed that the distribution of those plants had in-

creased since the photos were taken (S. Boyd, personal communication). Interpretations of habitat type and zonation in the Fraser River delta were aided by information from Yamanaka (1975), Moody (1978), and Hutchinson (1982). Although changes in the marsh communities have undoubtedly occurred since maps in those reports were produced, the visual patterns of intertidal plant zonation were expected to have changed insignificantly. All mapping was done using the GIS programs MapInfo and ArcView.

Estimates of Snow Goose numbers since 1987-1988 were obtained from Boyd (1995) and Pacific Flyway Council (2006*). The numbers of Snow Geese using agricultural fields were obtained from Boyd (1995) for the period 1987-1992, and from Canadian Wildlife Service et al. (1999*) for the period 1995-1998. Data on the Greenfields Program were obtained from Smith (1996*).

Because of variation and error inherently associated with parameters used in the analyses, a stochastic simulation model was developed. The model, run in MS Excel 98, incorporated published and unpublished data from several sources. Data in Imperial units (e.g., kcal) were converted to SI units (e.g., kJ). Stochasticity was incorporated in the model by randomly selecting values that were within the 95% confidence limits, or hypothesized range of some parameters.

The model in Appendix 1 was used to estimate the carrying capacity of the brackish marshes in the first half of the overwintering period ("autumn", versus the second half of the overwintering period: "spring"). Because the Fraser River delta experiences substantially more Snow Goose-days during autumn than in spring (Boyd 1995) and has less autumn habitat than spring habitat (as mapped in this study), I assumed that any habitat-imposed limitations on the geese would occur in autumn. Each simulation first calculated the metabolizable caloric value of the available *S. americanus*. From that value, the number of supportable Snow Goose-days was determined. In turn, Snow Goose-days (y) were used to estimate the size of the Fraser-Skagit segment (x) by using the inverse of the linear relation: $y = 47.764(x)$ ($P = 0.028$; $r = 0.89$; df = 5; y-intercept = 0) between "autumn" Snow Goose-days on the Fraser River delta and the size of the Fraser-Skagit segment as calculated from data presented in Boyd (1995). The y-intercept of this equation was set at 0 to account for segment sizes lower than those presented in Boyd (1995). Five thousand simulations were run.

A lack of data on two issues may have implications for the accuracy of the model's results, but because the parameters represented by these issues would not affect the model in a unidirectional manner, their implications are not viewed as necessarily troublesome. First, Burton et al. (1979) suggested that Snow Geese feed almost exclusively on rhizomes of *S. americanus* during autumn. In fact, however, Burton (1977, page 17) stated that Snow Geese strongly prefer both *S. americanus* and *S. paludosus* (the latter also known as *S. maritimus*). Unfortunately, as observed using gizzard contents, Burton (1977) could not differentiate between the cuticle reticulations of the rhizomes of the two species, thereby casting doubt on the accuracy of his conclusion about a dual food preference. Abundance of *S. maritimus* is about one-third that of *S. americanus* on the Fraser River delta (Yamanaka 1975). Second, the model assumes that all biomass grubbed by the Snow Geese is consumed by them. McIlhenny (1932; cited in Burton 1977) guessed that over-wintering Snow Geese in the southern United States rejected up to 10 times as much grubbed vegetation as they consumed. Burton (1977) felt that although some food rejection occurred on the Fraser River delta it did not likely approach those proportions.

Results and Discussion

Distribution, Abundance, and Carrying Capacity of Brackish Marshes in the Fraser River Delta

Autumn marsh habitat that is suitable for Snow Geese occurs in a narrow band along the western edge of the Fraser River delta's westernmost islands and near Brunswick Point (Figure 1). Most spring marsh habitat is similarly distributed. According to habitat mapping, the Fraser River delta contains 917.1 ha of "low marsh" habitat and 946.3 ha of "mid-high marsh" habitat in areas used by Snow Geese. Low marsh habitat is used by Snow Geese for "grubbing" bulrush rhizomes in the autumn period and mid-high marsh habitat is used in the spring for foraging on emergent sedges (Boyd 1995).

The results of autumn carrying capacity simulations of the Fraser River delta's brackish marshes are summarized in Figure 2. During autumn, brackish marshes can presently support a number of Snow Goose-days that is commensurate with a mean Fraser-Skagit segment size of 17 600 geese (range 7400-35 000). Numbers larger than this will exceed the calculated carrying capacity of brackish marshes during most years. According to the model there was only a 1.4% chance that >30 000 geese could be sustained by the brackish marshes (Figure 2). Those observations, and the conclusion that *S. americanus* biomass in the Fraser River delta is only ~15% of what it might support in the absence of Snow Goose grubbing (Boyd 1995), suggest that brackish marshes are either already over-grubbed or are at considerable risk of being over-grubbed.

Distribution and Abundance of Snow Geese on the Fraser River Delta

Numbers of Snow Geese in the Fraser-Skagit segment have been estimated from aerial photos of geese on the Fraser and Skagit river deltas (Subcommittee on White Geese 1992*; Boyd 1995; Pacific Flyway Council 2006*). Most use of the Fraser River delta occurs during early October to mid-January ("autumn") and from late February to mid-April ("spring"). Al-

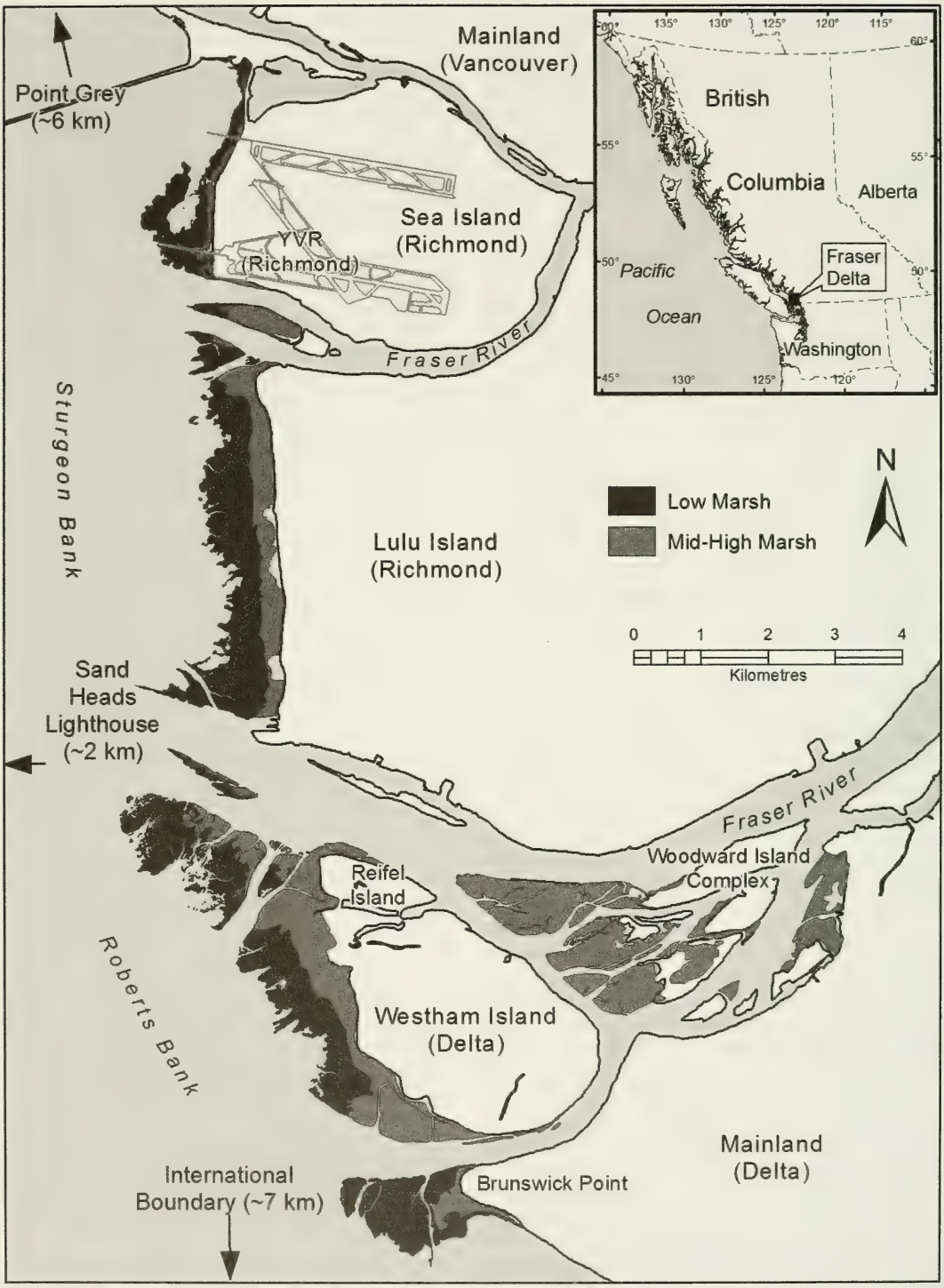

FIGURE 1. Distribution of intertidal marsh habitats used by Snow Geese during the autumn and spring periods on the Fraser River delta, British Columbia. Runways of the Vancouver international Airport (YVR) are indicated.

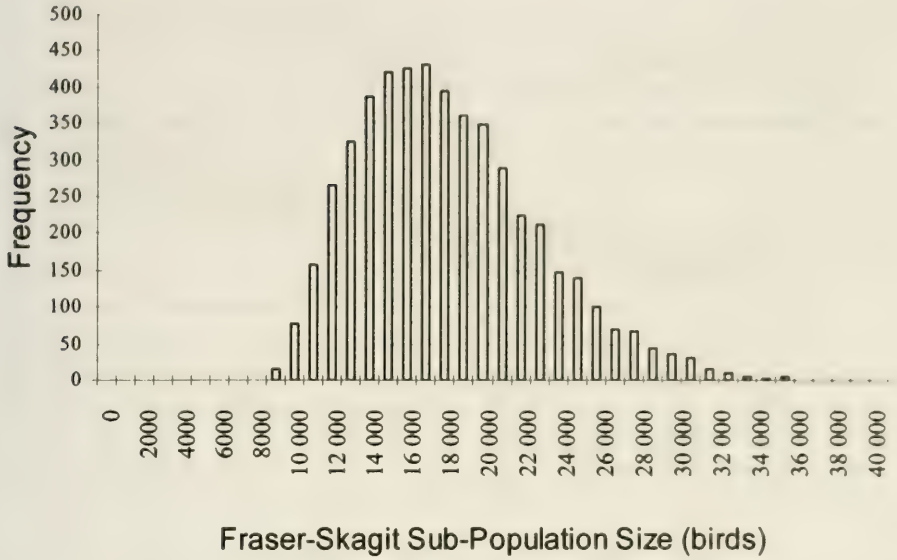

FIGURE 2. Simulation model results of the size of the Fraser-Skagit segment that could be supported by the brackish marshes of the Fraser River delta for Snow Geese during the autumn. 95% confidence interval on mean: 17 606 ±131 (n = 5000).

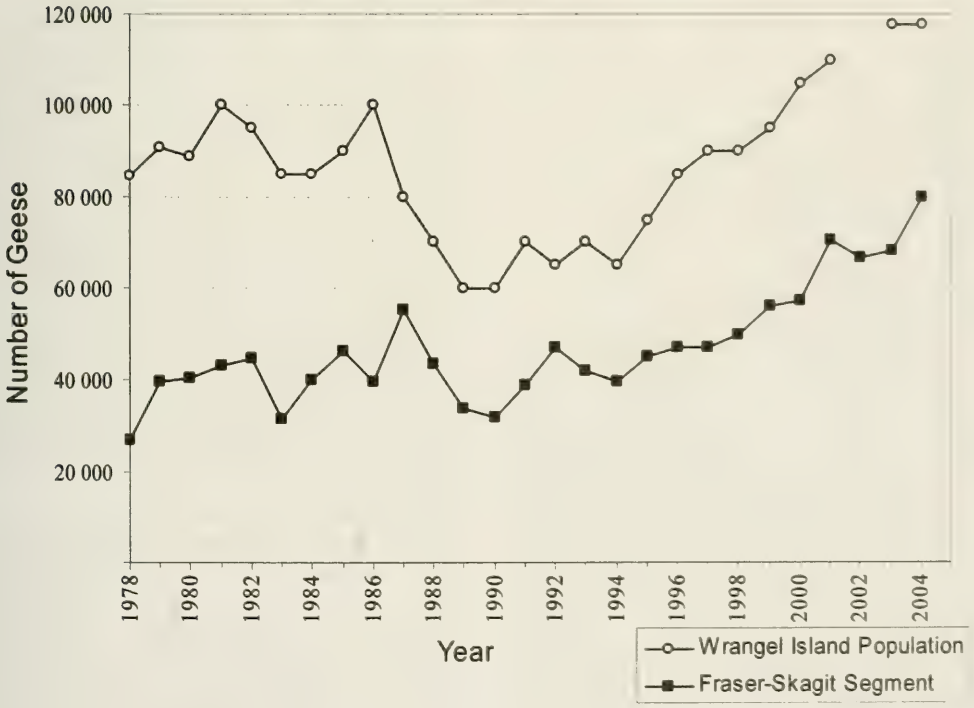

FIGURE 3. Estimates of the Wrangel Island Lesser Snow Goose Population size (total, spring) and size of the Fraser-Skagit segment (overwintering period beginning in year shown). Source: Pacific Flyway Council (2006*).

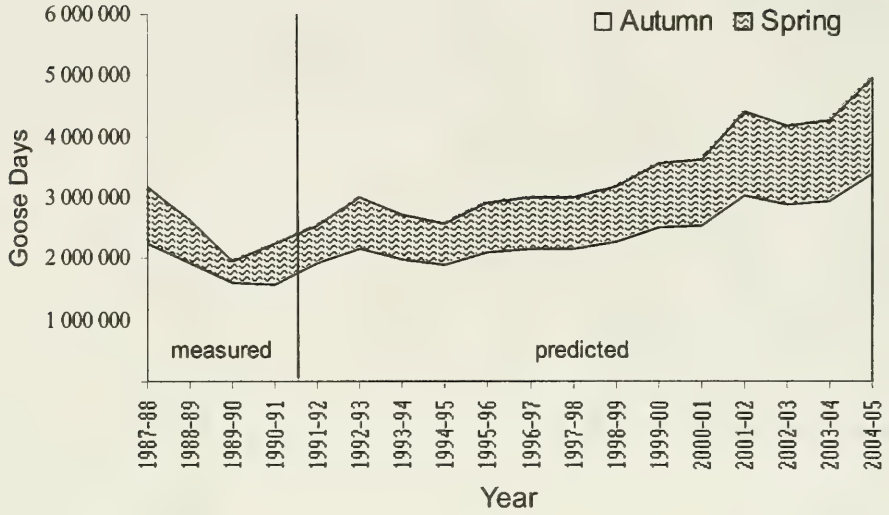

FIGURE 4. Stacked area chart showing measured and predicted number of Snow Goose-days on the Fraser River delta since 1987-1998. Data from 1987-1988 through 1991-1992 were measured by Boyd (1995). The remaining data were predicted using linear regression equations developed from data for the 1987-1988 through 1991-1992 period (Boyd 1995), and using population estimates (x values) from Pacific Flyway Council (2006*). Regression equations are as follows: (1) Autumn: y = 36.4(x) + 448 977 where y = autumn goose-days, and x = annual estimate of Fraser-Skagit segment ($P = 0.016$, $r = 0.94$, df = 4). (2) Spring: y = 22.7(x) - 221 987 where y = spring goose-days, and x = annual estimate of Fraser-Skagit segment ($P = 0.116$, $r = 0.78$, df = 4).

though geese occur on both deltas simultaneously during autumn and spring, most or all geese use the Skagit River delta for the four to five weeks between these periods. Since the winter of 1978-1979 (when the first photo counts on the Fraser and Skagit deltas were done) the Fraser-Skagit segment grew from ~27 000 birds (Pacific Flyway Council 2006*). Owing to high juvenile production and survival rates of Snow Geese, the Fraser-Skagit segment increased 3- to 4-fold in the late 1970s (Boyd 1995). Numbers of Snow Geese fluctuated in the 1980s then increased thereafter (Figure 3). Figure 3 shows an upward trend in the size of the Fraser-Skagit segment from 1978 through spring 2005 ($P < 0.001$; $r = 0.76$; df = 26). Recent surveys indicate that during the winter of 2004-2005 the segment was the highest ever recorded at ~80 000 birds (Pacific Flyway Council 2006*). From 1987-2005 the Fraser River delta sustained an estimated 2-5 million goose-days annually (Figure 4).

Farm fields apparently play an increasingly important role in the over-wintering ecology of the Fraser-Skagit segment of Snow Geese. The percentage of Snow Goose days spent on upland fields between 1987-1988 and 1991-1992 varied among years (Figure 5), but autumn-use, ranging between 7% and 30%, was typically much greater than spring use, which ranged from 0% to 20% (Boyd 1995). Although surveys of use of agricultural fields on Westham Island were conducted via ground counts from autumn 1995 through spring 1998 (cf. photo counts up to that point), the use of farm fields has increased in recent years. From 1995-1996 through 1997-1998, the use of farm fields on Westham Island (representing ~90% of all use of upland fields (S. Boyd, personal communication) ranged between 17% and 46% of the total number of goose days spent on the Fraser River delta in the autumn, and increased from 13% to 70% of such days in the spring (Figure 5). If foods in brackish marshes were being fully utilized, such a pattern would be expected if more goose-days were spent on the Fraser River delta. Indeed, Figure 4 shows a predicted increase in goose days over time and the linear relation between annual goose days on agricultural fields and size of the Fraser-Skagit segment is significant ($P = 0.002$, $r = 0.83$, df = 7); the lowest proportion of field-use occurred when the least number of goose days were spent on the Fraser River delta (1989-1990; Figures 4 and 5).

Snow Geese and the Brackish Marsh

The brackish marshes of the Fraser River delta are probably being over-utilized by Snow Geese. Model results indicate that the Fraser-Skagit segment exists at current levels only because the geese can also forage in upland fields. Maintaining numbers of Snow Goose above the carrying capacity of brackish marshes by way of providing supplemental feed on refuges and agricultural fields may degrade or continue to suppress the productivity of the brackish marshes. Boyd (1995) suspected that grubbing pressure by Snow Geese on

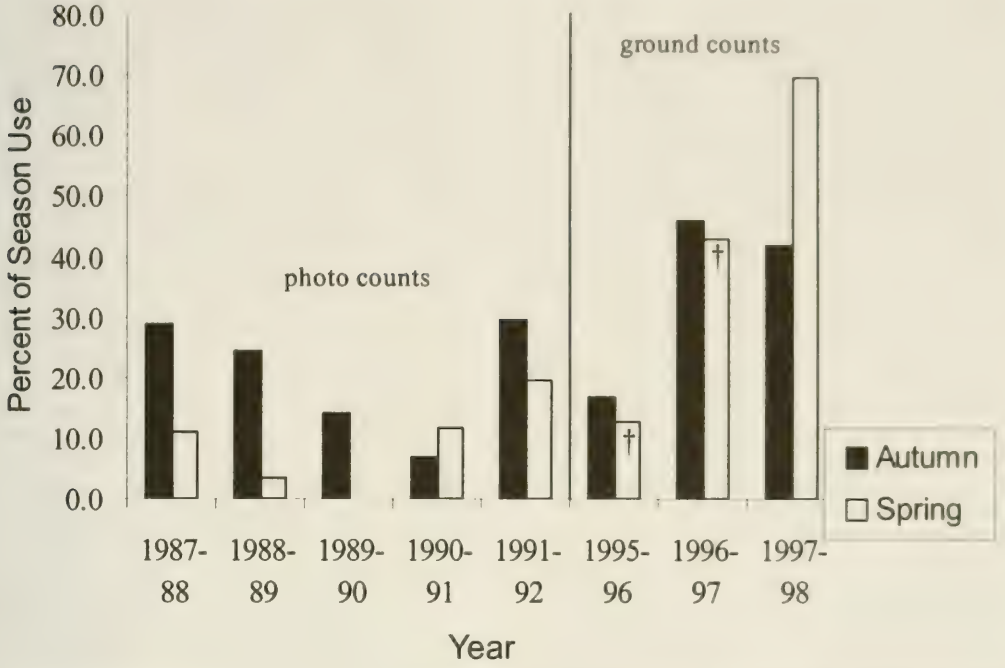

FIGURE 5. The estimated percentage of total Snow Goose-days on the Fraser River delta spent on agricultural fields during the "autumn" and "spring" seasons. Source: 1987-1992, Boyd (1995); 1995-1998, Canadian Wildlife Service et al. (1999*). †Spring use in 1995-1997 is likely underestimated because surveys ended several weeks before spring migration (departure).

parts of the Fraser Delta was contributing to a reversal in marsh succession. Boyd (1995) also speculated that the reason that production in the brackish marshes of the Skagit River delta was even lower (i.e., 10%) than the 15% figure reported for the Fraser River delta was because the Skagit River delta supported about twice as many goose-days as did the Fraser River delta during 1987-1992. Further, there is some concern that in recent years a greater proportion of the Wrangel Island population has been overwintering on the Fraser and Skagit deltas (Pacific Flyway Council 2006*).

If Snow Geese were excluded from all agricultural fields, including the sanctuary on Reifel and Westham islands, the segment would likely decline to a habitat-limited maximum size of ~15 000-20 000 birds. Although that scenario may be unrealistic, it is possible that changing land-uses and agricultural practices throughout the Wrangel Island population's winter range, in addition to changes in farmers' tolerance of Snow Geese in their fields, could direct even more foraging pressure onto brackish marshes. Regardless of farm-field availability, brackish marshes will always be vital for Snow Geese because during extended periods of freezing, the marshes are used exclusively (Boyd 1995). Use of marshes during cold weather likely reflects difficulties geese experience in obtaining food from the frozen or snow-covered soil of agricultural fields.

Snow Geese and Agricultural Fields

Forage from agricultural fields has contributed to the improved survivorship and subsequent population growth of Snow Geese in other parts of North America (Ankney 1996; Jeffries 1997). Possible reasons for the onset of, and increased use of, upland fields by Snow Geese on the Fraser River delta are not known with certainty, but it is plausible that rapid increases in the Snow Goose population during the late 1970s were largely responsible (Figure 3).

Burton (1977) predicted that if the Fraser-Skagit Snow Goose segment expanded beyond ~20 000 birds, the brackish marshes of the Fraser River delta would be adversely affected. Although estimates of *S. americanus* biomass in the mid 1970s (Burton 1977) and in the early 1990s (Boyd 1995) are not directly comparable due to different sampling strategies, a general review of the datasets suggests that rhizome densities during the early 1990s likely approximated those during the mid 1970s. This suggests that the brackish marshes were already being used to capacity by Snow Geese prior to the onset of farm-field use. Unfortunately, there are no data documenting trends in *S. americanus* biomass immediately following the rise in Snow

Goose numbers and onset of field use in the late 1970s and early 1980s so it is not known whether *S. americanus* biomass declined under more foraging pressure then merely rebounded as incremental foraging pressure on the delta shifted to upland fields.

The increased use of agricultural fields by the geese supports the hypothesis that the brackish marshes alone could not sustain the increased foraging pressure that a rising Fraser-Skagit segment was putting on the Fraser River delta. If the geese could not meet their energetic demands in brackish marshes, they would have been forced to explore alternate food sources such as those in agricultural fields. Several lines of evidence support this hypothesis.

First, from the perspective of Snow Goose foraging habitat, agricultural production suitable for Snow Geese in the local area has probably declined since the 1970s, both in areal extent and crop type (Boyd 1995). So, contrary to what might be expected, little or no use occurred when agricultural habitats were better for Snow Geese. According to W. Temple (DWFT, personal communication), there is no evidence that agricultural changes on the Fraser River delta influenced the initial use of upland habitats by Snow Geese in the late 1970s and early 1980s. W. Temple (personal communication) indicated that crops that Snow Geese presently use were grown for many years before the birds started using them. In 1993, farming of corn, peas, and beans by commercial processors on the Fraser River delta was largely halted (W. Temple, personal communication); thereby further diminishing the area of agricultural fields suitable for foraging Snow Geese. This likely put increased foraging pressure on other fields, and perhaps, on the brackish marshes.

Second, *S. americanus* stands in the Fraser River delta are at about 15% of their biomass potential in the absence of grubbing by Snow Geese (Boyd 1995). This suggests that the brackish marshes are not producing vast amounts of unutilized rhizomatous foods. Assuming a "steady state" between rhizome production and consumption, as reported by Boyd (1995), brackish marshes are being fully utilized (even overutilized) by consumers such as Snow Geese.

Third, Snow Geese on the Fraser River delta exhibit a high degree of site fidelity (Burton 1977; Boyd 1995). Thus, the full or partial abandonment of an area could indicate decreased habitat suitability. A lack of food in the traditionally used brackish marshes is a plausible reason why Snow Geese explored upland feeding areas. Such exploratory behaviour was predicted by Burton (1977) before the segment increased and before agricultural fields were used by the geese.

Finally, speculation that changes to hunting seasons and hunting areas in the Fraser River delta forced Snow Geese to use upland fields beginning in the late 1970s is not supported. The existence of a waterfowl refuge on Reifel Island has conceivably provided Snow Geese with upland foraging opportunities free of hunting pressure since the 1960s. Further evidence that hunting did not precipitate field use by Snow Geese is provided by Trumpeter Swans (*Cygnus buccinator*); a protected (i.e., unhunted) species since the 1930s. Trumpeter Swans and Snow Geese have similar diets during winter (Boyd 1995; Carter 1997). Trumpeter Swans have also experienced substantial increases in over-wintering populations in recent years. Carter (1997) noted that as numbers of Trumpeter Swans wintering near southwestern British Columbia have increased since the early 1970s, there has been a recent shift in habitat use from brackish marshes to agricultural areas. G. Fowler (CVWMP, personal communication) indicated that the use of agricultural fields by Trumpeter Swans in the Comox Valley on Vancouver Island, British Columbia, began in the mid-1970s. The onset of swan use of upland habitats was unlikely a response to any refuge effects provided by fields, as hunting for other waterfowl continues to this day on the same farm fields used by swans. Further, if swans were seeking refuge, the Courtenay River estuary (their traditional brackish-marsh wintering ground that has been largely abandoned as a foraging area in favour of upland sites) should still be used for foraging because it has been a no-shooting area since 1994. The swans roost in the estuary, but minimal feeding occurs there (G. Fowler, personal communication).

Conclusions

Currently, the increasing numbers of Snow Geese wintering on the Fraser River delta (~80 000 in 2004-2005; Pacific Flyway Council 2006*) exceed the modelled autumn carrying capacity of the area's brackish marshes (~17 500) by a large margin. As a result, the geese are highly dependent on forage provided in nearby agricultural and refuge fields. Despite compelling evidence that Snow Geese were grubbing *S. americanus* biomass to ~15% of its biomass potential since at least the early 1990s (Boyd 1995) and a doubling of the Fraser-Skagit segment from 1995-2005, the 2006 management plan (Pacific Flyway Council 2006*) only states that increasing numbers of Snow Geese *may* be reducing the biomass and extent of *S. americanus*. The Pacific Flyway Council (2006* page 13) recommends researching the "trends in biomass and growth dynamics of American Bulrush, impacts of grubbing by Snow Geese on intertidal marshes, and the carrying capacity of the Fraser-Skagit." The current plan relies on hunting to regulate the Wrangel Island population once it exceeds a 3-y average of 160 000 birds (Pacific Flyway Council 2006* page 32). As society's values and interests have shifted, sales of migratory bird hunting permits and participation in waterfowl hunting in British Columbia have declined steadily from 1974-2003 (Environment Canada 2005*). Hunting opportunity on the Fraser River delta has also diminished over time. Consequently, it is questionable that managers will be able to rely solely on hunting as a tool to effectively manage Snow Geese on the Fraser delta in the future.

Given that the brackish marshes are currently being used to (present) carrying capacity, any further increases in the Fraser-Skagit segment will likely require: (1) a substantial increase in the production of *S. americanus* rhizomes, (2) a concomitant increase in the use of agricultural fields by the geese, (3) natural selection for lower adult body weights, and thus lower gross energetic demands, or (4) a combination of these. Recognizing the reduced production of the brackish marsh, Boyd (1995) recommended that consideration be given to increasing the productivity of *S. americanus* by applying fertilizer. However, unless fertilization results in a yield of rhizomes exceeding that which Snow Geese could potentially consume, there is no reason to believe that Snow Geese would not consume fertilizer-induced growth back down to the "steady-state". The current management plan (Pacific Flyway Council 2006*) does not identify a need to research ways of increasing the carrying capacity of the marsh as was recommended in the 1992 plan (Subcommittee on White Geese 1992*).

By serving as food for herbivores and detritivores and as structural habitat (cover) for fish and invertebrates, healthy brackish marshes in the Fraser River delta are integral to an ecosystem that supports such key animals as White Sturgeon, Pacific Eulachon, Pacific salmon, shorebirds, and Snow Geese among many others. Large numbers of Snow Goose have negative implications not only for the brackish marsh ecosystem, but also for human safety. Bird hazard evaluations have concluded that Snow Geese pose an extreme hazard to civilian aircraft at the Vancouver International Airport on Sea Island (Demarchi and Searing 1995*). Consequently, an aggressive Snow Goose control program is necessary each winter near Sea Island to mitigate that hazard.

A prudent approach to managing the Wrangel Island population of Lesser Snow Geese would, at a minimum, be sensitive to Snow Goose conservation, potential adverse effects of Snow Geese on the brackish marsh ecosystem, and the interactions between Snow Geese and agriculture, air-traffic safety, and other land uses in the Fraser River delta.

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APPENDIX 1. Simulation model for the carrying capacity of the brackish marshes of the Fraser River delta for Lesser Snow Geese during the autumn. Model calculations were performed with MS Excel 98.

Row	Parameter	Units	Value (column C)	Source/Comment
2	Proportion juveniles (variable)	juvenile/adult	= RANDBETWEEN(0,5)/10	Boyd (1995)
3	Adult mean body weight	kg	2.357	McKelvey et al. (1989)
4	Juvenile mean body weight	kg	2.032	McKelvey et al. (1989)
5	Difference between juvenile and adult existence energy	kJ/d	209	King 1974 (cited in Frederick et al. 1987)
6	Existence energy at 0 C: Mean Adult	kJ/d	= (RANDBETWEEN(455,871))*C3-C5	Sedinger et al. (1995)
7	Existence energy at 0 C: Mean Juvenile	kJ/d	= (RANDBETWEEN(455,871))*C4	Sedinger et al. (1995)
8	Activity Increment above existence	variable coefficient	= RANDBETWEEN(11,17)/10	Taken as range of values between a "low" level of activity and the mean value from Table 7 of Frederick and Klaas (1982). Note: geese studied by Frederick and Klaas (1982) are believed to be more active than those on the Fraser River delta (S. Boyd, personal communication)
9	Metabolizible energy of *Scirpus americanus* rhizomes	kJ/kg	= RANDBETWEEN(5860,6700)	Burton et al. (1979)
10	*S. americanus* consumed: Adult Maintenance	kg/day	= C6/C9	Calculated
11	*S. americanus* consumed: Juvenile Maintenance	kg/day	= C7/C9	Calculated
12	Steady state *S. americanus* yield	$kg/m^2/y$	= RANDBETWEEN(22,36)/1000	Boyd (1995)
13	Total area of *S. americanus* marshes (low marsh)	ha	917.1	This study
14	Total Fraser River delta *S. americanus* yield	kg/y	= C12*C13*10000	Calculated
15	Proportion of grubbed *S. americanus* biomass consumed	fixed coefficient	1.0	A value of 1 assumes complete utilization
16	Metabolizable caloric value of *S. americanus* yield	kJ	= C14*C9*C15	Calculated
17	Fraser Skagit Snow Goose population	birds	= (((C16/(((C2*C7)+ ((1-C2)*(C6+C5)))*C8)))/47.764)	Calculated using regression: autumn goose-days in Fraser = 47.764*Fraser-Skagit segment Data from Boyd (1995); y-intercept = 0; df = 5; $r^2 = 0.80$

ADDENDA

Last Flight?

My third, and supposed final, flight of 10 November 2005 was in a De Havilland Dash 8 that was to take me home from a journey that began a few hours earlier in a 6-seat Piper Navaho that departed from a snow-covered gravel strip in northern B.C., then continued in a Bombardier CRJ from Prince George to Vancouver (YVR). The westbound departure from YVR's runway 26L would take us over the marsh along the foreshore of Sea Island. It was like so many others I've been on since 1994 when I began studying bird-hazards to aircraft at YVR and helped develop their 24/7 wildlife control program to mitigate those hazards—many of which I had witnessed first-hand. There I was, wondering what critters might be flying around in the flight path this time. For night-time flights such as this, my usual thoughts turn to some poor, unsuspecting barn owl out patrolling the airfield in search of a plump vole. But this time a far more serious hazard was pondered: snow geese that breed in the Russian arctic and winter here by the tens of thousands. By chance, I had just submitted a manuscript for publication earlier in the week, addressing adverse effects of a burgeoning snow goose population on the Fraser Delta. And two days earlier on final approach I had spied a flock of geese loafing in the marsh near the flight path. I had heard recently that the wintering flock this year was bigger than ever.

With plenty of runway lights still below us, we levitated steeply into the darkness. By the time we were over the marsh, we'd reached an altitude that, based on my numerous hours of field-observations from a ground station near the runway's end, led me to believe that we had cleanly escaped the main bird-hazard zone yet again. Still, I peered out the right side at the faintly illuminated propeller hauling us into the blackness.

At some 300+ km/h in the dark there was no chance for more than a glimpse of three or four whitish blurs, accompanied by subtle impact vibrations so transient that I can't remember if they were heard, felt, or both. Snow geese? Gulls? "Shit!" seemed like the right thing to say, so I did as I sat there with a helpless feeling wondering what, if any, damage had been done, and on tenterhooks bracing for more white blurs that, luckily, didn't appear.

As the craft began its usual roll toward Victoria I said to myself, "Okay, maybe I'm making this out to be a bigger deal than it is," thinking that my heightened awareness of bird hazards probably causes me to fret more than I should. Except this time, the turn continued a bit longer so that instead of heading over the Strait of Georgia, we were heading southeast over the lights of Delta. I knew something was amiss. Then the captain announced that we'd hit some birds and that we were going back to YVR for an "inspection". Well, at least the plane sounded okay and I couldn't see any evidence of severe damage like fire or smoke. Touchdown, taxi, stop, shutdown, back home—sort of.

Sitting on the apron and watching an aircraft mechanic inspect the wing, cowling, and what looked to be a bloodstained propeller (I surmised that blood does not show up so clearly on a black background) some questions arose. Can his flashlight look-see really pronounce the plane safe? Should I just grab my gear, walk off this plane and board another? Is it too late to catch a ferry? I sat there knowing that bird-strikes are not that uncommon and that by choice or not, the simple fact that I choose to fly means that I must have some faith in our air industry's standards and its technicians and mechanics. Besides, what could I know of the condition of any other aircraft in the fleet? When the captain announced that the plane was damaged and that we would have to deplane and board another, well, let's just say that I was not put out.

As deftly handled by the gate crew on what was already a very busy evening for regional air-travel out of Gate C38, within an half an hour 37 of the original 50 of us were lining up to board a shorter Dash 8. The others might seek the calming benefit of a pint or two before catching their ride. On the way out of the covered walkway I engaged the ground crewman's humour about this time we should avoid the "shredded tweet"; taking it as a reference to the fact that this mustn't be a particularly unique event if it's got its own pun. Yet I must say that his humour was tempered somewhat by my second-hand knowledge of the deadly havoc a few birds can wreak when they strike the "wrong" parts of a fully loaded, outbound plane.

I'm happy to report the most exciting thing about the fourth of my supposed three plane rides that day was the "free" candy. Home safe (but a little shaken) in time for dinner. My next trip to YVR will be on Thursday. Faith be with me.

MIKE W. DEMARCHI
12 November 2005

Predicting Raccoon, *Procyon lotor*, Occurrence Through the Use of Microhabitat Variables

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Recent increases in Raccoon (*Procyon lotor*) abundance have been implicated for decreased nesting success of songbirds and transmission of rabies. Understanding the relationship between occurrence and microhabitat factors should be helpful in managing this species, though our current understanding of this relationship is inadequate. Therefore, we conducted a study in western Tennessee during 2000–2002 to determine this association. Occurrence (capture) data were assessed from results of live trapping at 176 and 112 trap sites during winter and summer, respectively, at three sites. A maximum of 26 habitat variables were measured at each trap location; all grids were combined for statistical analyses to account for varying relationships between occurrence and microhabitat factors across different landscapes. Univariate and stepwise logistic-regression analyses were used to assess associations among microhabitat variables and occurrence. Resulting models were validated through the jackknife procedure. Predictive equations were constructed from logistic-regression models to compute capture probabilities. Univariate analyses yielded numerous significant variables with those representing forest characteristics and proximity to water generally the most significant. Strong concordance was observed between winter and summer seasons for most variables though several differed (number of large hardwood snags, ground dens, and plant food species, distance to potential water and roads). Such temporal variability was expected due to seasonal differences in habitat components and biological needs of Raccoons. Variables included in derived models were similar to those scoring highest in univariate analyses; classification rates for models (winter = 72%; summer = 78%) were among the highest recorded for generalist species. By accounting for landscape attributes and replicating across sites, more accurate and useful models were developed. Such models should provide the information required to effectively manage this species.

Key Words: habitat partitioning, logistic regression, mesopredator, microhabitat, *Procyon lotor*, Raccoon, western Tennessee.

Raccoons (*Procyon lotor*) and their associated habitats have been the subject of several biological investigations (see Lotze and Anderson 1979; Kaufmann 1982; Broadfoot et al. 2001; Gehrt 2003). At a landscape level, this medium-sized predator (mesopredator) is thought to be most abundant in aquatic associated habitats (Johnson 1970; Minser and Pelton 1982). However, Raccoons can thrive in an array of habitats although seeming to depend on particular features to reach high and stable populations (Broadfoot et al. 2001; Zeveloff 2002). Several investigators (i.e., Morris 1987; Pedlar et al. 1997; Chamberlain et al. 2002) have noted that knowledge of spatial scale and landscape composition is integral to understanding habitat associations of species, though at present, much of the understanding of the relationship of Raccoons to their habitat is based on assumptions drawn from investigations (e.g., Sanderson 1987; Minser and Pelton 1982; Oehler and Litvaitis 1996) conducted at the landscape level (macrohabitat). The relationship between the occurrence (defined as presence at a location) of Raccoons and microhabitat factors has not been studied at multiple sites collectively and findings of previous investigations (Leberg and Kennedy 1988; Kennedy et al. 1991; Kissell and Kennedy 1992; Pedlar et al. 1997) indicate various associations depending on season and location. Currently the relationship between the occurrence of Raccoons and habitat variables appears to be unclear and in need of additional study (Kissell and Kennedy 1992; Chamberlain et al. 2003), and models allowing for the prediction of occurrence based on microhabitat factors are lacking from the published literature.

Previous studies (Noss et al. 1996; Oehler and Litvaitis 1996; Rogers and Caro 1998) have indicated that due to a combination of factors (e.g., removal of top predators, altered land use, reduced hunting), abundance of mesopredators has increased in recent years. Estes (1996) noted that increased mesopredator populations could influence numerous aspects of ecosystems. For example, high densities can have negative effects on populations of ground-nesting birds (Crabtree and Wolf 1988; Vickery et al. 1992; Schmidt 2003) and, by enhancing the spread of diseases, can impact negatively the health of populations (Carey and McLean 1983; Hill et al. 1993; Schuburt et al. 1998; Rosatte 2000). Predators play an important role in structuring biological communities (Meffe et al. 1997), and an increase in abundance of these species requires strong management

and conservation planning to limit the negative impact of these taxa on ecosystems. However, sound management and conservation plans are difficult to derive without a clear understanding of specific habitat factors critical to target species. At this time, managers of natural resources are faced with increasing populations of Raccoons but limited habitat information on which to make management decisions (see Rosatte 2000 for the consideration of habitat factors in controlling rabies). In particular, models allowing for the prediction of Raccoon occurrence are lacking. For example, certain factors are important components in determining Raccoon occurrence (e.g., den sites and aquatic habitats, Pedlar et al. 1997; Broadfoot et al. 2001; Henner et al. 2004). However, the exact relationship among these components is not known, thereby requiring individuals to make management decisions without the necessary information (i.e., containing rabies outbreaks, Rosatte et al. 2001). Therefore, the purpose of this study was to assess at a microhabitat scale the relationship of occurrence of Raccoons (based on capture frequency) with selected habitat factors from multiple sites representing a mosaic of habitat types. Specifically, the following predictions were assessed: (1) there is an association between occurrence (based on capture) and selected (individual) habitat variables; and (2) selected habitat variables can be used to construct models predictive of species occurrence.

Study Area

This study was conducted in temperate deciduous forest in western Tennessee characterized by a fragmented landscape consisting of various levels of forest, early successional and agricultural fields, residential buildings, and road systems at three sites. Site 1 was located at the Edward J. Meeman Biological Station (Meeman), which was located approximately 20 km north of Memphis, Tennessee (35°33'N, 90°09'W). This location was comprised primarily of hardwood forests with old-field and Kudzu (*Pueraria lobata*) habitats interspersed throughout. Old-fields were dominated by goldenrod (*Solidago* spp.), fescue (*Festuca* spp.) and Switch Grass (*Panicum virgatum*). Topography of the site was characterized by numerous drainages that resulted in a gently rolling terrain throughout the area. Upland and bottomland forests included various oaks (*Quercus* spp.), hickories (*Carya* spp.), and maples (*Acer* spp.) as well as Tulip Poplar (*Liriodendron tulipifera*) and Sweet Gum (*Liquidambar styraciflua*; Maris 1998). Several small ponds and intermittent streams occurred throughout the site.

Sites 2–3 were located at the Ames Plantation (Ames; 35°06'N, 89°12'W), which was a 7462 ha farm located northwest of Grand Junction in Fayette and Hardeman counties, and was operated by The Hobart Ames Foundation in cooperation with the University of Tennessee. Ames was located approximately 79 km southeast of Meeman. Site 2 was located adjacent to the North Fork of the Wolf River. It was comprised primarily of agricultural fields and bottomland hardwood forest with some upland forest present. Site 3 was composed of upland and bottomland forest, cropland, and old-field habitats. In general, agricultural crops included Soybeans (*Glycine max*), Corn (*Zea mays*), and cotton (*Gossypium* spp.). Typical upland tree species were Loblolly Pine (*Pinus taeda*), oaks, and hickories; typical bottomland species included oaks, maples, Cottonwood (*Populus deltoides*), and Sweet Gum (Gabor 1993). Old-field habitats included native warm season grasses and were similar to those at Meeman. Topography of upland forest sites was characterized by gently rolling slopes, whereas bottomland forest, old-field, and agricultural areas constituted a flatter topography. Ponds and intermittent streams were numerous, and drainages were interspersed throughout all of these sites.

Methods

Trapping grids were established at each site. Site 1 followed a 5 × 10 trap configuration with traps located approximately 150 m apart. Sites 2–3 followed an 8 × 8 trap configuration with traps located approximately 230 m apart though two trap locations were excluded from analysis for site 2 as habitat factors were not measured. Difference in trap configuration for site 1 was due to the limited size of the area. Collectively, the three sites represented most habitat types occurring in western Tennessee.

The association of microhabitat variables and occurrence of Raccoons was assessed during two periods that coincided with times when leaves were present or absent (winter and summer, respectively) on most woody and herbaceous vegetation (Kolowski and Woolf 2002). During winter, sites were operated on selected nights from 3 November–7 April, 2000–2002; summer trapping included only sites 1–2 and were operated on selected nights from 7 May–12 October, 2001–2002. An approximate total of 2000 trap nights (one trap night = one trap set for one night) were observed for each site during both seasons.

Raccoon-size Tomahawk (Number 108; Tomahawk Live Trap Co., Tomahawk, Wisconsin, USA) and Havahart (Woodstream Corporation, Lititz, Pennsylvania, USA) live traps were used. Traps were baited with canned cat food in winter and a combination of cat food, dog food, and doughnuts in summer. Initially captured individuals were anesthetized with a mixture of ketamine hydrochloride (Ketaset; Bristol Laboratories, Syracuse, New York, USA) and acepromazine maleate (PromAce; Ayerst Laboratories, New York, New York, USA) at a 10:1 ratio with 0.1 cc of ketamine hydrochloride used per estimated kg of live weight (Bigler and Hoff 1974). Raccoons were tagged in both

ears with Number 3 Monel (National Band and Tag Company; Newport, Kentucky, USA) ear tags to determine recaptures.

For the winter season, 19 habitat variables were measured to determine the influence of habitat at the micro-scale on raccoon occurrence. "Slope" represented the average percentage slope for a 32 m radius around the trap site as measured by a clinometer. "Total basal area" [≥5 cm diameter at breast height (dbh)], "basal area of small trees" (5–35 cm dbh) and "basal area of large trees" (>35 cm dbh) represented the amount of area (m^2) covered by trees per hectare and were determined through use of a prism sweep (10 basal area factor prism) conducted at the trap site and at two additional sites 11.4 m in two random cardinal directions. Heights were recorded for each tree measured during the basal area estimation using a haga altimeter (Forestry Suppliers, Inc., Jackson, Mississippi, USA) with the mean recorded as "average height". "Number of fallen logs" (≥10 cm in diameter) "number of total snags" (≥10 cm dbh), "number of small hardwood snags" (10–35 cm dbh), "number of large hardwood snags" (>35 cm dbh), "number of pine snags" (≥10 cm dbh), "number of ground dens", "number of tree dens", and "number of total dens" were counted within a 32 m radius of trap site. An opening of ≥5 cm in diameter was required to be considered a potential den. The "number of plant food species" represented the number of plant species present within a 32 m radius of the trap site that could be utilized as food sources. The "number of stems" 1–5 cm in diameter was counted for a 3.2 m radius around the trap site. The procedure was repeated in two random cardinal directions 11.4 m from the trap site and the average used. "Distance to potential water" represented the nearest distance to a water source that held water ≥30 days a year. "Distance to permanent water" was the minimum distance to a water source that held water ≥11 months a year. "Distance to road" was measured to the nearest road or man-made vehicular trail, while "distance to open area" represented the nearest distance to a non-forested patch. All distance measurements were in meters and were measured using digital orthophoto quarter-quadrangles georeferenced in ArcView software.

Seven additional variables were assessed during the summer season yielding a total of 26. "Depth of leaf litter" was averaged from 10 random measurements taken within a 32 m radius around the trap site. "Vertical cover" was assessed through the use of a 2 m × 0.2 m cover board checkered with 0.1 × 0.1 m black and white squares. The percentage of board uncovered was recorded at the trap site in all four cardinal directions. The percentage of squares uncovered on a spherical densiometer (Forestry Suppliers, Inc., Jackson, Mississippi, USA) was recorded to determine "canopy cover". Readings were taken in all 4 cardinal directions at the trap site. "Grass cover", "woody cover", "forb cover", and "bare soil cover" were visually estimated for a 3.2 m radius around the trap site. All procedures for measuring summer variables (except "depth of leaf litter") were repeated in two random cardinal directions 11.4 m from trap site and the average used.

Because the purpose of this investigation was to assess at a microhabitat scale the relationship of occurrence of Raccoons from multiple sites, statistical analyses were conducted only on data from all sites combined for both winter and summer seasons. A natural log transformation was applied to all continuous variables; percentage variables were arcsine transformed to approximate a normal distribution (Zar 1999). Univariate logistic regression was used to assess associations between single habitat variables and Raccoon occurrence with a non-adjusted $\alpha = 0.05$ to indicate significance following suggestions by Moran (2003).

In stepwise logistic-regression analyses, an $\alpha = 0.15$ was used as a minimum threshold for inclusion into the regression function to reduce the data set (Hosmer and Lemeshow 2000). Multicollinearity effects between two significant variables were addressed by assessing correlations among habitat variables. If two significant variables were correlated at $r \geq 0.70$, only the more significant variable of the pair was included in further analyses to reduce redundant variables (Agresti 1996).

Variables remaining after univariate logistic regression were included in a backward stepwise logistic-regression function and were removed from the model at $P > 0.15$. Subsequent models often contained a large number of variables. Therefore, for practicality and management purposes, these models were reduced further by forcing exclusion of variables with lowest t ratios resulting in a minimum variable model. The t ratio represents the ratio of each regression coefficient to its standard error. Relative importance of variables included in the final models was ascertained through t ratios, with maximal t ratios reflecting the best variable to predict occurrence (Hacker and Coblentz 1993; Hosmer and Lemeshow 2000; Kolowski and Woolf 2002).

Percentage correct classification of trap sites was determined using logistic regression models. Accuracy of these models was determined using the jackknife procedure as a pseudo-validation technique (Morrison 1976; Kolowski and Woolf 2002). This procedure tested percentage correct classification by removing one trap site at a time and then classified that site based on the model built from all other sites combined, resulting in a less-biased percentage classification (Hacker and Coblentz 1993; Kolowski and Woolf 2002). All statistical procedures were conducted using SYSTAT 10.0 (SPSS 2000).

Results

Trapping resulted in 209 total captures of 112 individual Raccoons obtained from 176 trap sites in winter

TABLE 1. Resulting *t* ratios and *P* values from univariate logistic regression of captures of Raccoons (*Procyon lotor*) compared to habitat variables at three sites during winter and two sites during summer 2000–2002 in western Tennessee. All variables are considered significant at $P < 0.05$. Basal area measurements are per ha. Height and distance measurements are in m. See text for explanation of variables.

	Winter (n = 12454)		Summer (n = 8406)	
Variable	*t* ratio	*P* value	*t* ratio	*P* value
Slope	2.517	0.012[a]	1.878	0.060[a]
Total basal area	4.986	<0.001	3.593	<0.001[a]
Basal area of small trees	4.252	<0.001[a]	3.400	0.001
Basal area of large trees	5.516	<0.001[a]	3.447	0.001[a]
Average height	4.052	<0.001	2.433	0.015
Number of fallen logs	4.548	<0.001[a]	2.653	0.008[a]
Number of total snags	2.677	0.007	1.753	0.080[a]
Number of small hardwood snags	1.506	0.132	1.647	0.100
Number of large hardwood snags	2.786	0.005[a]	-0.205	0.838
Number of pine snags	2.579	0.010	1.494	0.135
Number of ground dens	1.947	0.052	0.412	0.680
Number of tree dens	3.399	0.001[a]	2.556	0.011[a]
Number of total dens	3.410	0.001[a]	2.265	0.024[a]
Number of plant food species	4.411	<0.001[a]	-0.046	0.963
Number of stems	2.657	0.008[a]	2.140	0.032[a]
Distance to potential water	-6.045	<0.001[a]	-0.170	0.865
Distance to permanent water	-2.045	0.041[a]	-3.158	0.002[a]
Distance to road	0.908	0.364	2.645	0.008[a]
Distance to open area	3.669	<0.001[a]	2.023	0.043[a]
Depth of leaf litter			0.699	0.485
Vertical cover			-0.843	0.399
Canopy cover			-3.018	0.003[a]
Grass cover			0.182	0.855
Woody cover			1.353	0.176
Forb cover			-0.742	0.458
Bare soil cover			3.052	0.002

[a] Variable included in stepwise logistic-regression function.

(site 1 = 100 total captures of 49 individuals; site 2 = 40 total captures of 26 individuals; site 3 = 69 total captures of 37 individuals) and 173 total captures of 117 individuals from 112 trap sites in summer (site 1 = 93 total captures of 52 individuals; site 2 = 80 total captures of 65 individuals).

Winter.—Sixteen habitat variables were significant statistically when compared to Raccoon occurrence using univariate logistic regression; greatest positive associations occurred for basal area of large trees and total basal area, whereas the strongest negative association was for distance to potential water (Table 1). The only habitat variable not closely related to Raccoon occurrence was distance to road. Through stepwise procedures and model construction, six variables (four positive, basal area of large trees, number of plant food species, number of tree dens, basal area of small trees; two negative, distance to potential water, number of total dens) were selected (Table 2). Percentage of trap sites correctly classified was 72%.

Summer.—Thirteen habitat variables were significantly associated to Raccoon occurrence based on univariate logistic regression; strongest positive associations were for total basal area, basal area of large trees, basal area of small trees, and bare soil, whereas distance to permanent water and canopy cover had the strongest negative associations (Table 1). In general, variables associated to basal area, height of stand, number of logs, den sites, canopy cover, number of stems, bare soil, and distances to permanent water, roads, and open areas were associated to occurrence; variables not associated to occurrence included snags, leaf litter, food species, vertical density, vegetative ground cover, and potential water sources. Three significant variables (two positive, total basal area, distance to road; one negative, distance to permanent water) were selected through subsequent stepwise procedures and model construction resulting in the correct classification of 78% of trap sites (Table 2).

Discussion

Univariate analyses yielded numerous significant variables indicating those selected for the current investigation influenced Raccoon occurrence. These variables were similar to those correlated in previous investigations (e.g., association with forest characteristics,

TABLE 2. Regression coefficients, *t* ratios, and *P* values (*P*) for Raccoons (*Procyon lotor*) derived from logistic-regression functions, as well as percentage correct classifications using the jackknife procedure. Data included in analyses were as follows: winter = three sites totaling 12454 trap nights; summer = two sites totaling 8406 trap nights. See text for explanation of variables and sampling locations.

		Logistic regression			Jackknife classification		
Season	Variable	Coeff	*t* ratio	*P*	No capture[a]	Capture[b]	Combined
Winter	Constant	-4.605	-10.656	<0.001	70	72	72
	Distance to potential water	-0.251	-4.671	<0.001			
	Basal area of large trees	0.194	2.732	0.006			
	Number of plant food species	0.491	2.583	0.010			
	Number of total dens	-0.389	-2.249	0.024			
	Number of tree dens	0.381	2.081	0.037			
	Basal area of small trees	0.149	2.046	0.041			
Summer	Constant	-4.605	-7.034	<0.001	57	88	78
	Distance to permanent water	-0.338	-4.177	<0.001			
	Total basal area	0.355	3.322	0.001			
	Distance to road	0.230	2.656	0.008			

[a] Percentage correct classification of sites with no captures.
[b] Percentage correct classification of sites with captures.
[c] Percentage correct classification of all sites combined.

Leberg and Kennedy 1988; Kennedy et al. 1991; Pedlar et al. 1997; Dijak and Thompson 2000; association with water sources, Leberg and Kennedy 1988; Dijak and Thompson 2000) and suggest that a strong component of forested areas with large trees and close proximity to water sources are important factors in predicting Raccoon occurrence. Additional variables significant in the present investigation were not significant in other studies (e.g., average height, slope, and distance to roads — Leberg and Kennedy 1988; Kissell and Kennedy 1992). This lack of concordance may be attributed to differences in landscape composition and a lack of replication (Maurer 1986; Temple and Wilcox 1986; Oehler and Litvaitis 1996). Baldwin (2003) found similar results when addressing individual sites for Virginia Opossums (*Didelphis virginiana*) in western Tennessee. However, by assessing multiple sites, noticeable trends were observed. The lack of concordance for individual sites was attributed to differing landscape compositions. By assessing multiple sites of similar landscape composition, the difference in significant habitat factors dissipated. Similar results were observed for Striped Skunks (*Mephitis mephitis* — Baldwin et al. 2004) and suggest that landscape composition is an important factor when constructing models predictive of occurrence (Temple and Wilcox 1986; Dijak and Thompson 2000).

Differential use of habitat by Raccoons across seasons has been documented (e.g., Lotze and Anderson 1979; Kaufmann 1982; Chamberlain et al. 2002), although quantitative assessments of these shifts among seasons have received little study. Nevertheless, concordance of significant variables across seasons was generally high although a few exceptions were noted. For example, large hardwood snags and ground dens were important factors during winter but were non-significant during summer. Both variables provide thermal shelter for Raccoons during winter (Stains 1961; Sanderson 1987) but may be less important during warmer seasons. Likewise, number of plant food species and distance to roads were significant factors during winter but not in summer. The non-significance of these variables may be related to the abundance of food and the lack of hunter use of roads during summer. This non-use of roads as travel corridors may have resulted in increased use of stream banks during winter (Hilty and Merenlender 2004), thus yielding different results between seasons for distance to potential water. Ultimately, temporal variability should be expected due to seasonality in variables measured as well as in the biological needs of Raccoons and should be considered when modeling Raccoon occurrence.

Most previous investigations have attempted to determine those factors most important in influencing Raccoon occurrence at the micro-scale but did not include modeling techniques in their analyses (Leberg and Kennedy 1988; Kennedy et al. 1991; Kissell and Kennedy 1992; but see Pedlar et al. 1997 for different modeling strategy). Such modeling strategies allow for the prediction of heavy-use areas by Raccoons and are particularly useful to managers of natural resources. Therefore, such procedures were incorporated into the current investigation and yielded models that generally included the strongest variables from univariate analyses (i.e., forest and water characteristics). Resulting models maintained high classification rates while allowing managers to focus only on those variables most important for predicting Raccoon occurrence. Such techniques have yielded slightly higher classification rates for habitat specialists [Fisher (*Martes pennanti*) = 79% — Carroll et al. 1999; Iberian Lynx (*Lynx*

pardinus) = 83% — Palma et al. 1999] likely due to their need for more specific habitat components. Nonetheless, classification rates observed in the current study are generally higher than those reported for other habitat generalists [Bobcat (*Lynx rufus*) = 59–70% — Kolowski and Woolf 2002; Striped Skunk = 56–75% — Baldwin et al. 2004]. Therefore, models that utilize replicated sites and account for differences in landscape composition could serve as a blueprint for future investigations involving habitat generalists ultimately resulting in models more useful for wildlife managers. Unfortunately, construction of such models can be expensive. Care must be taken to develop an appropriate sampling strategy to maximize results.

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Notes

Scoter, *Melanitta* spp., Migrations Interrupted by Confederation Bridge: An Update

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Bunker-Popma, Katherine. 2006. Scoter, *Melanitta* spp., migrations Interrupted by Confederation Bridge: An update. Canadian Field-Naturalist 120(2): 232-233.

Continued monitoring over 10 years of scoter migrations through Northumberland Strait confirmed that these birds continue to perceive the Confederation Bridge (completed in 1997) as an obstacle. Such problems – and alternatives not causing them – need serious consideration when "strait crossings" are contemplated elsewhere.

Key Words: Scoters, *Melanitta* spp., migrations, Northumberland Strait, bridge, New Brunswick.

While the Confederation Bridge (46°15'N, 63°40'W) linking Prince Edward Island to New Brunswick was being completed in 1997, Hicklin and Bunker-Popma (2001) examined the possible influence of the bridge upon migration by marine birds. They concluded that migrating scoters (*Melanitta* spp., seaducks) were unwilling to fly under the (40 metre high) bridge and often reluctant to fly over it.

Earlier information, recently supported by several studies (e.g. Wilson et al. 2003*), suggested that, in recent years at least, most migrating scoters passing through the Maritime Provinces in spring cross the Chignecto Isthmus 40-50 km. further west and do not approach the Confederation Bridge. Much less is known about their fall migrations.

TABLE 1. Ten years of scoter movement at Confederation Bridge, New Brunswick/Prince Edward Island. Spring (S) and fall (F) totals shown separately for each year.

Year		Observation time (hr)	Scoters seen to approach bridge	Scoters seen to pass over bridge* (%)	
1997	S	54	731	243	(33)
	F	102	876	338	(39)
1998	S	15	70	29	(41)
	F	49	923	388	(42)
1999	S	4	16	0	
	F	78	1495	881	(59)
2000	S	35	389	67	(17)
	F	74	1675	859	(51)
2001	S	16	212	115	(54)
	F	72	906	431	(48)
2002	S	18	461	150	(33)
	F	70	1368	725	(53)
2003	S	27	604	129	(21)
	F	50	1824	1274	(70)
2004	S	28	515	275	(53)
	F	47	1253	696	(56)
2005	S	11	46	6	(13)
	F	22	435	156	(36)
2006	S	14	124	68	(55)
	F	40	1038	547	(53)
Totals	S	222	3168	1082	(34)
	F	604	11793	6295	(53)
Grand Totals		826	14961	7377	(49)

* No scoters were seen to pass under the bridge

I monitored seaduck migrations at Confederation Bridge each year since 1997, using procedures of our original study (Hicklin and Bunker-Popma 2001) to see if these birds habituated to the perceived obstacle. Results of these observations, summarized in Table 1, suggest that the majority of scoters still, after 10 years, have not learned a simple, general, way of passing the bridge.

Nearly half of those seen (34% in spring, 53% in fall) circled upwards and passed extremely high over the bridge without landing. Others landed on the water, and remained there, often for hours. Still others followed the bridge towards the opposite shore, and sometimes were lost to sight while still flying. As my observations do not suggest that birds in the two latter categories stay near the bridge indefinitely, presumably they continue their migrations later, but timing of their departures and the routes followed remain unknown.

Given the small fraction of regional scoter populations that approach it, this bridge cannot be considered a major obstacle to their migrations, at a flyway level. Nevertheless, the continuing problem posed to the birds that encounter this bridge needs to be borne in mind whenever and wherever bridges are proposed in locations traversed by major portions of migratory species populations.

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A. J. Erskine edited my original draft and encouraged publication of this update.

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An Observation of the Spring 2006 Migration of Black Scoter *Melanitta nigra*, in Northumberland Strait, Interrupted by the Confederation Bridge, New Brunswick – Prince Edward Island

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MacKinnon, Colin, and Andrew Kennedy 2006. An observation of the spring 2006 migration of Black Scoter *Melanitta nigra*, in Northumberland Strait, interrupted by the Confederation Bridge, New Brunswick – Prince Edward Island. Canadian Field-Naturalist 120(2): 233-234.

An observation from the bridge of a flock of Black Scoters suggests that, nine years after construction, the 12.9 km Confederation Bridge may still be a partial barrier to bird migration. Only 3 of 18 scoters (16.7%) crossed over the structure during the observation period.

Key Words: Black Scoter, *Melanitta nigra*, seaducks, migration, Confederation Bridge, Northumberland Strait, New Brunswick, Prince Edward Island, Cape Jourimain National Wildlife Area.

Construction of the Confederation Bridge began in 1995 and was completed in 1997. This 12.9 km concrete structure spans the Northumberland Strait at its narrowest point between the Cape Jourimain National Wildlife Area, New Brunswick, and Borden, Prince Edward Island. As part of collecting pre-construction baseline data in 1990, MacKinnon et al. (1991) monitored seabird and seaduck movement through the Northumberland Strait. Twenty-two hours of surveys, during spring and fall, produced 5214 observations on 25 species. Of these, 2041 (39.1%) were seaducks, 1400 (26.9%) were three species of scoters and 641 (12.3%) were Common Eider, *Somateria mollisima* (MacKinnon et al. 1991).

During the early 1990s, concerns were expressed over possible effects the Confederation Bridge may have on seabird migration. The closest comparable existing structure was the Canso Causeway, connecting Cape Breton Island with mainland Nova Scotia. Erskine and Smith (1986) reported that, although the causeway was a comparatively low and short structure, Common Eider were believed to have treated the structure as a barrier to flight. A flock of eiders flew parallel to the causeway, gained altitude, and eventually crossed over. The question was, would seaducks do the same with the Confederation Bridge?

In 1997, Hicklin and Bunker-Popma (2001) conducted surveys at Confederation Bridge during spring

migration, similar to those reported by MacKinnon et al. (1991). The Confederation Bridge was then operational, and their observations suggested that it formed a partial barrier to scoter migration. Of 3986 and 1441 scoters observed by them during respective spring and fall migration, only 12.8% of scoters crossed over the bridge during the spring and slightly more, 21.9%, in the fall. Bunker-Popma (2006) subsequently reported additional years of observation.

The Confederation Bridge utilizes a multi-span concrete box girder structure and is composed of three main components: the approaches (east and west), a 40 m-high deck and 60 m-high ship-navigation span. The east approach is 0.6 km over 7 piers and the west approach is 1.3 km over 14 piers. The main bridge is 11.0 km (44 piers) in length. In the middle of the bridge is a 2.50 km navigation section. The typical span, between piers, is 250 m.

The Confederation Bridge has been in operation for nine years. During the morning of 13 April 2006, we observed the behaviour of a flock of Black Scoters, *Melanitta nigra,* during their northward migration (46°13'N, 63°44'W). This observation proved more interesting as the authors were travelling across the bridge, by vehicle, at the time and were able to track the flock's activities over most of the crossing. At the time of observation, visibility was excellent, no clouds, +6°C and wind light SSW.

Shortly after we entered the Confederation Bridge from Borden, Prince Edward Island, at 08:10, a flock of 18 Black Scoters was observed flying parallel with and approximately 100 m south of the Bridge at a height of approximately 40 m above the water. The flock was observed to rise and approach the bridge deck on three occasions. On two occasions, the flock approached the deck and then veered back to its original flight path, parallel with the Bridge. On the third occasion, the flock gained altitude and, similar to the previous occasions, aborted its attempted flight over the bridge after coming within approximately 50 m of the structure. However, this time the flock completed a clockwise circle, towards the bridge, in order to regain their original flight path. At the instant in which the flock began this circle, three birds broke from the main group and promptly crossed over the Bridge, behind our vehicle, at a height of approximately 10 m above the bridge deck. This crossing occurred approximately 4.5 km from the Prince Edward Island side of the bridge. The velocity of the flock was constant with our driving speeds of about 80 km/h, until it could no longer be viewed in the vicinity of the navigation channel. While rising over the navigational channel, the scoters remained out of sight below us. We maintained a constant speed of 80 km/hr and the flock was immediately re-sighted once we descended from the elevated navigation span. Upon re-locating the flock, we noted that the group had decreased in size, while out of sight, from 15 to 8 birds. We did not observe any scoters coming into view on the north side of the Bridge and assume the missing seven birds did not cross the structure. The remaining eight birds eventually landed in the water approximately 100 m south of the bridge and 500 m from the New Brunswick coastline (46°10'N, 63°49'W). Observations ceased at 08:25. It is noteworthy that the Confederation Bridge is built in a general "S" curve, thus the flight of the scoter flock was following the contours of the bridge and not a straight line.

This observation demonstrates that nine years after the Confederation Bridge was built, some seaducks, such as Black Scoters, still may perceive the structure as a partial barrier to their northward migration through the Northumberland Strait.

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First Record of a River Otter, *Lontra canadensis*, Captured on the Northeastern Coast of Alaska

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Haskell, Shawn P. 2006. First record of a River Otter, *Lutra canadensis*, captured on the northeastern coast of Alaska. Canadian Field-Naturalist 120(2): 235-236.

A River Otter (*Lontra canadensis*) was captured on the Beaufort Sea coast of northeastern Alaska during a coastal fish study in late July 2001. The otter was dead upon retrieval and of adult size. River Otter distribution is not known to extend north of Alaska's Brooks Range. This occurrence may have represented a one-time spring dispersal event. However, fluviomorphological features of some river systems may provide suitable habitat for an overwintering otter in this region of Alaska's North Slope.

Key Words: River Otter, Beaufort Sea, *Lutra canadensis*, fyke net, distribution, Alaska.

In late July 2001, a River Otter (*Lontra canadensis*) of adult size was retrieved from a shoreline fyke net in Lions Bay, a barrier island lagoon system on the Beaufort Sea coast of northeastern Alaska. The live-capture fishing net was located at 70°10.024'N, 146°12.557'W, approximately 82 km east of Prudhoe Bay and 11 km west of the Canning River; the nearest non-industrial areas of human habitation are Barter Island, 100 km to the east, and the Colville River delta, 170 km to the west. A westerly wind event had caused coastal water levels to rise, completely submerging the trap-end of the net in about 1.5 m of water, drowning the otter. Physical samples or measures were not taken of the specimen. The animal was discarded to the water at the capture site. About two weeks after the capture, the author retrieved the carcass for brief examination. Marine arthropods of the family Mysidae had entered all openings in the otter's body, expediting decomposition.

River Otter distribution is commonly noted as extending far north up the Mackenzie River drainage of northwestern Canada but then falling south of the Alaskan Brooks Range to the west (Rue 1981; Whitaker 1996; Forsyth 1999; Wilson and Ruff 1999). Bee and Hall (1956) reported a River Otter sighting in the central Brooks Range at Kanayut Lake and tracks observed near the Beaufort Sea coast at the Kuparuk River. Manville and Young (1965) also displayed a point location near the mouth of the Kuparuk River, but given survey methods, that point may stem from the same observation of tracks documented by Bee and Hall (1956). A commercial winter fishery operated in the Colville River Delta since the early 1950s has never captured a River Otter (James Helmericks, homesteader and naturalist, personal communication). There are only two state sealing records for River Otters in Alaska's North Slope region; one was caught near Wainwright in northwestern Alaska in 1990 and the other near Anaktuvuk Pass in the central Brooks Range in 1985 (Geoff Carroll, Alaska Department of Fish and Game Area Biologist, personal communication). Biologists have reported seeing small numbers (i.e., one or two) and tracks of otters north of Anaktuvuk Pass but south of the Arctic Coastal Plain on the Anaktuvuk and Chandler rivers, both tributaries to the north-flowing Colville River, where freshwater upwellings provide open water throughout winter and habitat for fishes such as Arctic char (*Salvelinus alpinus*; Geoff Carroll, Alaska Department of Fish and Game Area Biologist, personal communication).

It is unknown whether the 2001 otter capture in Lions Bay signified an anomalous extralimital occurrence or a case of regular periodic use by otters of this area seldom occupied by humans. Leffingwell (1919) noted that larger rivers in the region supported populations of fish year-round. Relatively small catches of juvenile amphidromous fishes during the summers of 1999 and 2001 in Lions Bay indicated that these fish, and likely some adults of the same species, did overwinter in the area (Griffiths et al. 2002*). Craig and McCart (1974*) identified groundwater springs in the nearby Kavik River and Canning River drainage, as well as a field of *aufeis* in the Canning River Delta, that supported overwintering fish. Some of these areas could potentially provide suitable habitat for an overwintering otter on Alaska's North Slope.

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Osprey, *Pandion haliaetus*, Depredates Common Eider, *Somateria mollissima*, Duckling

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To our knowledge, we present the first published account of a successful attack on a Common Eider (*Somateria mollissima*) duckling by an Osprey. Ospreys were sighted periodically during 940 hours of Common Eider observations in June-August, 2001 on Grand Manan Island, New Brunswick. One duckling (<1 week old) was observed depredated by an Osprey. Vulnerability of ducklings to predation may promote such opportunistic behaviour. The rarity of observations of such incidents suggests depredation on ducklings by Osprey is uncommon.

Key Words: Common Eider, *Somateria mollissima*, Osprey, *Pandion haliaetus*, predation, Grand Manan Island, New Brunswick.

The diet of Ospreys (*Pandion haliaetus*) consists almost exclusively of live fish (Poole et al. 2002). Coastal populations may switch prey species depending on the pattern and timing of fish migration (Greene et al. 1983). Ospreys are known to feed occasionally on rodents, birds, reptiles, amphibians, and invertebrates (see Wiley and Lohrer 1973 for literature review). Birds reported include grebes, gulls, ducks, including a 2-week old Wood Duck (*Aix sponsa*; Wiley and Lohrer 1973), and passerines (Chubbs and Trimper 1998).

From 7 June to 3 August 2001, a study of Common Eiders (*Somateria mollissima*) was conducted on Grand Manan Island located 35 km from the New Brunswick south shore. It is the largest (25 km long, 11 km wide) of 17 other islands in the archipelago. A total of 940 hours of observations were made at eight 1 km^2 sites, typically between 06:00 and 21:00 h. Duckling numbers and ages were recorded at 20-minute intervals using scan sampling (Altman 1974). Predatory attacks were recorded as they occurred. Eider broods occupied the intertidal zone which was covered with brown fucoid algae (*Ascophyllum nodosum* and *Fucus vesiculosus*) with some rock, sand or mud. A mixed forest of Balsam Fir (*Abies balsama*), spruce (*Picea* sp.) and alder (*Alnus* sp.), as well as shrubs (*Rubus* sp.) and various grasses (Graminae) were usually present within 10-50 m of the high tideline. A vertical tidal range of up to 8.4 m can be expected in this area. Approximately 3370 Common Eider pairs (Ronconi and Wong 2002) and 15 other Anatidae species breed in the archipelago (Dalzell 1991).

On 4 July 2001, an Osprey of unknown breeding status captured and carried off a 0-7 day-old eider duckling approximately 100 m offshore. The researcher (V. V.) was situated near the waterfowl sanctuary of Castalia Marsh (44°42'N, 66°48'W). Just prior to the attack, an eider crèche of 25 adult females and 62 ducklings was observed in the area dabbling for invertebrates. Duckling ages and counts (number) in this group were 0-7 days old (18), 8-13 days old (38), and 14-21 days old (6). At 20:00, the crèche stopped foraging and became alert when an Osprey flew nearby before leav-

ing the site. It returned at 20:03, swooped down, took an eider duckling without any defensive behaviour by the hens, and flew out of sight. The presence of the duckling in the raptor's talons was verified using a Bushnell *Spacemaster* 45-60 × 200 spotting scope. Ospreys were not observed at Castalia for the remainder of the evening. Ospreys were recorded at Castalia and at five other sites during visits both before and after the attack. Only lone Ospreys were seen at any given time, and no nests were present within any of the study sites. Bald Eagles (*Haliaeetus leucocephalus*) also took three ducklings at Castalia and two ducklings at another site approximately 10 km away.

One of the reasons suggested to explain Ospreys taking non-fish prey is reduced visibility caused by turbid water (Chubbs and Trimper 1998). Machmer and Ydenberg (1990) found that capture rate by Ospreys decreased greatly when winds were above 25.2 km/h. On the evening of the attack, moderate winds (~13 km/h), medium-sized waves and clear skies probably did not contribute to poor fishing conditions, although incoming tide and floating algae could have made fish less detectable.

Ospreys may take easily-captured (usually weak or captive) birds when available (Dement'ev and Gladkov 1951). Eider ducklings <3 weeks old have poorly developed diving skills (Hamilton 2001). This makes them vulnerable to predation, especially in the first 10 days of life, with reported mortalities exceeding 90% from gull attacks (Mawhinney and Diamond 1999). Because Ospreys cannot dive deeper than one meter into water (Prevost 1982), they forage in shallow-water environments (Poole et al. 2002). Shallow-water areas are often near brood-rearing habitat of eiders (McAloney 1973).

In spite of many hours of observation of eider crèches in waters surrounding Grand Manan Island, we observed only one instance of duckling depredation by an Osprey. Ducklings less than one week old, which are vulnerable to predation, were observed during five out of eight observation periods (63%) and during 32 out of 309 scans (10%) at Castalia. Therefore, it seems unlikely that this Osprey was a "specialist"; i.e., fed more frequently on ducklings than the average rate for the species. Predation on eider ducklings by Ospreys is evidently a rare event everywhere.

Acknowledgments

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Extension de l'aire de distribution de l'Umbre de vase, *Umbra limi*, dans le nord-est du Québec

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Desroches, Jean-François. 2006. Extension de l'aire de distribution de l'Umbre de vase, *Umbra limi*, dans le nord-est du Québec. Canadian Field-Naturalist 120(2): 238-239.

Le 26 juillet 2005, plusieurs Umbres de vase (*Umbra limi*) ont été capturés au secteur Les Buissons de Pointe-aux-Outardes, sur la Côte-Nord au Québec. Ces mentions élargissent l'aire de distribution de ce poisson de 300 km vers le nord-est.

On 26 July 2005, we caught many Central Mudminnows (*Umbra limi*) at the Les Buissons sector of Pointe-aux-Outardes, on the Côte-Nord region of Québec. These records extend the known distribution of this fish 300 km to the northeast.

Mots-Clés: Umbre de vase, Mudminnow, *Umbra limi*, distribution, aire de distribution, Québec

L'Umbre de vase (*Umbra limi*) se retrouve dans le centre de l'Amérique du Nord, du centre-sud des États-Unis jusqu'au sud du Canada, vers le nord (Page et Burr 1991). Au Canada, il est réparti d'ouest en est depuis l'Alberta jusqu'au Québec (Scott et Crossman 1974). Au Québec, l'espèce est confinée au sud-ouest de la province, se rendant à l'est jusque dans la région de la ville de Québec selon les données actuellement disponibles (Scott et Crossman 1974; Bergeron et Brousseau 1981; Bernatchez et Giroux 2000).

En juillet 2005, dans le but de capturer des amphibiens aquatiques, deux nasses à ménés ont été placées dans un étang à castors situé dans le secteur Les Buissons de Pointe-aux-Outardes (49°7'47"N; 68°21'36"O). Les nasses ont été relevées le 26 juillet 2005. Dans la première nasse, il n'y avait aucune capture, mais quelques Umbres de vase ont été capturés en fouillant dans l'eau avec une épuisette. Neuf spécimens, soit quatre jeunes (longueur totale 27,0-30,7 mm) et cinq adultes (longueur totale 54,5-62,7 mm) ont été gardés et sont conservés dans la collection de poissons du Musée canadien de la nature (CMNFI 2005-0032). Dans la seconde nasse se trouvaient une jeune Anguille d'Amérique (*Anguilla rostrata*) vivante et les restes de deux Umbres de vase, probablement dévorés partiellement ou régurgités par l'anguille. Des fouilles effectuées avec une épuisette ailleurs dans l'étang, la même journée, ont permis la capture de quelques autres Umbres de vase et de têtards de grenouilles.

Cet étang à castors est relié à un lac plus gros, le lac Lagacé, qui a une superficie d'environ 6 ha (850 m × 85 m). Le contour de l'étang est irrégulier, l'eau est teintée de brun, et on y retrouve quelques arbres morts. Il présente certains méandres vaseux où l'on retrouve un peu de végétation aquatique submergée. La forêt bordant l'étang est mixte et composée notamment d'épinettes (*Picea* sp.), de Sapin baumier (*Abies balsamea*) et de Bouleau blanc (*Betula papyrifera*). Des aulnes (*Alnus* sp.) bordent l'étang.

L'Umbre de vase est une espèce tolérante reconnue pour vivre dans des eaux chaudes et riches en végétation, généralement peu oxygénées (Scott et Crossman 1974). Dans le sud-ouest du Québec, on le trouve dans les baies riches en végétation des lacs et rivières lentes, dans les étangs à castors et les étangs de tourbières, et dans les fossés (observation personnelle). Les plans d'eau retrouvés sur la Côte-Nord sont en général des lacs clairs typiques à l'Omble de fontaine (*Salvelinus fontinalis*), habitat peu propice à l'Umbre de vase. On y retrouve également des étangs à castors et des tourbières, lesquels sont plus favorables à l'espèce. L'Umbre de vase pourrait donc se retrouver ailleurs sur la Côte-Nord.

La découverte de l'Umbre de vase sur la Côte-Nord au Québec, à 300 km au nord-est de sa distribution actuellement connue, revêt un intérêt particulier. Il apparaît probable que ce poisson soit plus répandu qu'on le croyait au Québec et qu'il ait été sous-inventorié. Il s'agit d'une petite espèce ne présentant aucun intérêt pour la pêche sportive ou commerciale et vivant le plus souvent dans des milieux peu propices aux poissons convoités pour la pêche. Ces facteurs contribuent sans doute à la méconnaissance de sa distribution dans le nord du Québec, et possiblement sur la rive sud du Saint-Laurent vers l'est. Il est également possible que cette population d'Umbres de vase soit le fruit d'une introduction volontaire ou accidentelle par des pêcheurs les ayant prélevés plus au sud, dans le but de s'en servir comme appâts de pêche. Des inventaires mieux ciblés permettraient de préciser la distribution de cette espèce au Québec.

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The Mink Frog, *Rana septentrionalis*, in Southeastern Labrador

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Desroches, Jean-François, Isabelle Picard, and John E. Maunder. 2006. The Mink Frog, *Rana septentrionalis*, in Southeastern Labrador. Canadian Field-Naturalist 120(2): 239-240.

Mink Frogs (*Rana septentrionalis*) were collected at three new localities in southeastern Labrador in 2003 and 2005, extending the known range of the species about 200 km to the east, to the limits of the coast.

La Grenouille du Nord (*Rana septentrionalis*) a été trouvée dans trois nouvelles localités dans le sud-est du Labrador en 2003 et 2005. Ces mentions élargissent l'aire de répartition connue de l'espèce d'environ 200 km vers l'est, aux limites de la côte de l'Océan Atlantique.

Key Words: Mink Frog, *Rana septentrionalis*, range, Labrador.

The Mink Frog (*Rana septentrionalis*) has the most northerly southern limit of any North American anuran (Hedeen 1986). This southern limit ranges from southern Manitoba and northern Minnesota, south and east through Wisconsin, northern Michigan and southern Ontario, then northeast through northern New York, northern New England, New Brunswick, and Nova Scotia (Conant and Collins 1998; Cook 1984; Hedeen 1986). The species has recently been introduced on the island of Newfoundland (Warkentin et al. 2003). Its northern limit remains poorly known, largely because the species is particularly aquatic (Hedeen 1986) and its call and appearance are unfamiliar to many observers. In Labrador, the Mink Frog has been documented from several scattered localities, though not from the extreme north or southeast (Maunder 1983, 1997; Cook 1984; Desroches and Rodrigue 2004).

In 2003, during a primarily botanical and malacological field trip for the Provincial Museum of Newfoundland and Labrador (JEM), and in 2005, during a vacation trip (J-FD and IP), we surveyed ponds and brooks along all of the main roads and smaller town access roads of southeastern Labrador, as far to the northeast as the town of Cartwright.

On 3 August 2003 a single adult Mink Frog, found freshly dead from unknown causes, was collected (NFM HE-250) from the shoreline of a medium-sized pond, located beside the access highway running between the Trans-Labrador Highway and the town of Cartwright, about 39.5 km southwest of the road junction to the town of Paradise River (53°09'52"N; 57°31'56"W). This locality was, at the time, about 100 km east of the known range of the species (number 1 in Figure 1). The water of the pond was clear.

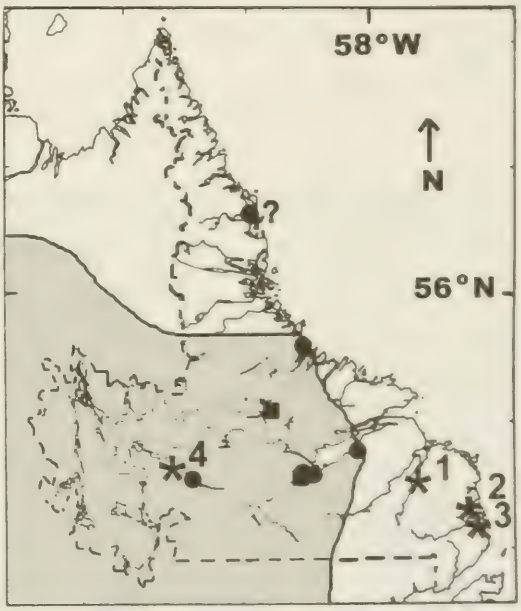

FIGURE 1. The Mink Frog in Labrador. Previous records: dots (Maunder 1983) and squares (Maunder 1997). Question mark: Questionable record (see Maunder 1983: 42, 44). Gray zone: proposed distribution based on previous records (Bleakney 1958; Cook 1984; Desroches and Rodrigue 2004). Stars: New records in southeastern Labrador (1: southwest of Paradise River, 2: Charlottetown, 3: St. Lewis, 4: east of Churchill Falls). Broken line: Labrador-Québec border.

The dominant emergent plants were Yellow Pondlily (*Nuphar variegata*), Narrowleaf Bur-reed (*Sparganium angustifolium*), and Water Lobelia (*Lobelia dortmanna*). The shoreline of the pond was mainly gravelly, over a boulder substrate, and was well-vegetated. The surrounding habitat was *Kalmia* scrub heath, with patches and strips of low Black Spruce (*Picea mariana*) woods in more sheltered areas.

In 2005, Mink Frogs were observed at two additional localities in southeastern Labrador, about 200 km east of the former known range of the species (numbers 2 and 3 in Figure 1). On 11 July, a subadult Mink Frog was collected (CMN-35805) from a small pond located beside a gravel road in the town of Charlottetown (52°46'09"N; 56°06'59"W). The pond was about 60 × 15 m in size, and had clear water, a muddy bottom, and grassy and rocky shores. Trees at the site were mostly Black Spruce. On 18 July, two Mink Frog tadpoles were collected (CMN-35810) by dipnetting at Blue Hill Pond, St. Lewis (52°24'55"N; 55°55'45"W). The pond had clear water, a sandy and rocky bottom, and some emergent plants near the shore. It was bordered by Sweet Gale (*Myrica gale*) and alder (*Alnus* sp.), and the adjacent forest was dominated by Black Spruce. Two Threespine Sticklebacks (*Gasterosteus aculeatus*) were caught in the same habitat, but released.

In 2004, an additional observation of the Mink Frog was recorded at St. Lewis by Christian Fortin (Fortin 2005) but no voucher specimen was collected (C. Fortin, personal communication).

In 2005, Mink Frogs were also observed in western Labrador, near the site of an old record, along the Trans-Labrador Highway, east of the town of Churchill Falls (53°29'29"N; 63°40'06"W) (number 4 in Figure 1). Two adults and one subadult were collected (CMN-35798). Although this observation is not a range extension it is included here because it is a new collection record.

During our searches for amphibians in southeastern Labrador, the only other species observed was American Toad (*Bufo americanus*). Tadpoles of this species were seen and/or collected at five locations along the roads.

The new Mink Frog collections recorded in this paper show that the species is more widespread in southeastern Labrador than has been previously documented. Further Labrador surveys should emphasize areas north of the presently known distribution of the species.

Acknowledgments

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First Record of the Great Barracuda, *Sphyraena barracuda* from Canada

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Balkwill, Darlene, Brian W. Coad, Ismael Galvez, and John Gilhen. 2006. First record of the Great Barracuda, *Sphyraena barracuda*, from Canada. Canadian Field-Naturalist 120(2): 241-242.

We report the collection, and provide a description, of the first Great Barracuda, *Sphyraena barracuda*, in Canadian waters based on a partial skeleton from Country Island, Nova Scotia.

Key Words: Great Barracuda, *Sphyraena barracuda*, new record, fish fauna, Nova Scotia, Canada.

The cranium, lower jaw and attached trunk vertebrae of a Great Barracuda, *Sphyraeana barracuda* (Family Sphyraenidae), were found dried on a beach on Country Island, Guysborough County, Nova Scotia at 45°06'00"N, 61°32'37"W in May 1999 by Ismael Galvez. This is the first record for this species from Canada (Scott and Scott 1988; Coad et al. 1995). The specimen is catalogued in the Nova Scotia Museum of Natural History, Halifax, under NSM 85385.

Description

Three species of barracuda are reported from the western Atlantic Ocean north of Florida, *Sphyraena barracuda* (Walbaum, 1792), *S. borealis* DeKay, 1842, and *S. guachancho* Cuvier in Cuvier and Valenciennes, 1829. Only *S. borealis* has been recorded from Canada, a single specimen from Halifax Harbour, Nova Scotia, caught on 5 October 1928 (Scott and Scott 1988). Carpenter (2002) records *S. barracuda* and *S. guachancho* from Massachusetts (rare) southwards.

Our specimen is neither *S. borealis* nor *S. guachancho* on the basis of length, these two species generally reach maximums of 46-50 cm, (commonly) 35 cm and 50-60 cm, respectively (De Sylva 1984; Robins and Ray 1986; Carpenter 2002). Murdy et al. (1997) give 1 m for the latter species. Our specimen is close in size to a disarticulated specimen of *S. barracuda* in the Royal Ontario Museum (ROM R6281; pur-

FIGURE 1. Photograph of skeletal remains of a Great Barracuda from Country Island, Guysborough County, Nova Scotia (NSM 85385)(bottom) with skull of ROM R6281 above.

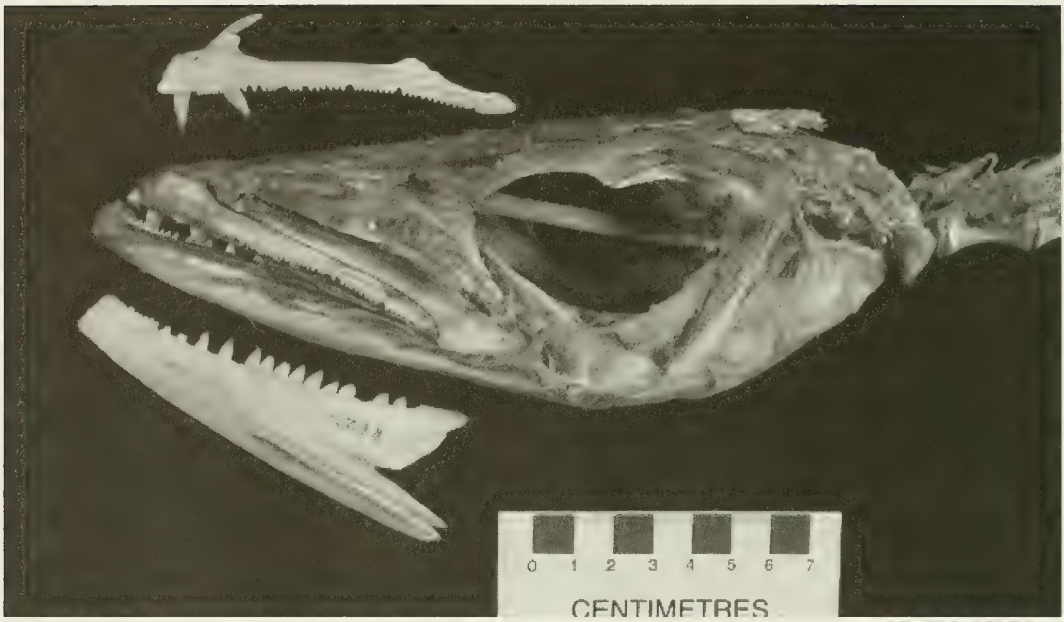

FIGURE 2. Photograph of skeletal remains of a Great Barracuda from Country Island, Guysborough County, Nova Scotia (NSM 85385) flanked by the upper and lower jaws of ROM R6281.

chased from Kensington Fish Market, Toronto, and thought to be from the Caribbean area) that has a recorded total length of 86.0 cm. The length of the dorsal skull surface (from the anterior tip excluding the upper jaw to the origin of the supraoccipital crest) is 135.1 mm in NSM 85385 and 116.8 mm in ROM R6281. These measurements make the Nova Scotian specimen ca. 99.5 cm total length. NSM 85385 has a head length of ca. 181.7 mm (the opercular bone is somewhat curved) and FishBase (www.fishbase.org) states that head length is 17.7% total length, giving a total length for the Nova Scotian specimen of 1.03 m. These two forms of measurement agree, making the Nova Scotian specimen about 1 m long in life. This unequivocally eliminates *S. borealis* and probably *S. guachancho*.

Other, osteological, characters also strongly suggest the Nova Scotian specimen is a Great Barracuda. The specimen has the area between eyes flat (convex in *S. guachancho*), teeth are contiguous, vertically flattened and erect (conical and widely spaced in *S. borealis*, angled backwards in *S. guachancho*), and the tip of the maxilla reaches past the anterior orbit margin (not reaching the orbit in *S. borealis*) (De Sylva 1984; Murdy et al. 1997; Carpenter 2002; comparative material of *S. guachancho* ROM R1837 and R2706).

We consider it unlikely that this specimen came from a local fish market and was imported. One of us (JG) has not seen this species on sale locally. The shore of Country Island is remote from commercial sites. It probably represents a stray that died in Canadian waters and was washed ashore.

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Book Reviews

ZOOLOGY

Animal Skulls – A Guide to North American Species

By Mark Elbroch. 2006. Stackpole Books, 5067 Ritter Rd., Mechanicsburg, PA 17055. 727 pages, $34.65 Paper.

As an instructor of comparative vertebrate anatomy, and a self-proclaimed enthusiast of skulls, I very much looked forward to reading and reviewing this book. I learned a fair amount from this book, mostly regarding animals that don't live in my area, so overall, this book was for me, a valuable read.

There is an enormous amount of material synthesized in this book. There are the expected figures illustrating the skull bones from a number of species; neighbouring figures illustrate the measurements most commonly used. However, the figure for reptiles has several errors, and those for the birds and mammals also have a few...not a good start for fundamental material near the beginning of the book.

Skulls of each species are illustrated in three views within the species accounts. Elsewhere, montages of dorsal views (mammalian and herp crania) and lateral views (mammalian mandibles, birds) are quite useful, and where practical, are illustrated at life-size. Even though the skulls in these montages show less detail than in the species accounts, I've always found this set-up useful (as in the *Golden Field Guide to Birds*, where warblers and sparrows are illustrated in a similar manner).

There are a number of issues that I found annoying. Why, for instance, is the Mantled Howler Monkey described (and illustrated along with two other species of non-human primate)? They are native to Central and South America; Are they feral in North America? We are never told. We are never told of the distributions of any of the animals, a shortcoming if someone is trying to identify a skull they've found based on this book. Secondly, the author is somewhat free with his use of the word *bone*. "Occipital condyles", for instance, are *processes* of bones, not bones unto themselves, though that is how they're treated. In a book that thankfully retains appropriate terminology, this oversight will be undetected by the novice, but irritating to the experienced. I now need to shout..."Molars are not flat!" I have to remind my students of this constantly. In English, we have the two words, "flat" and "broad", and they are not interchangeable. Molars adapted for grinding vegetation are broad...they are anything but flat as erroneously described numerous times in this book. There are a few other annoying errors in this vein. Given the number of prominent, pre-publication reviewers mentioned in the acknowledgements, one must wonder about their diligence to this project.

The title is awkward, *Animal Skulls* (as opposed to part two in the series, *Plant Skulls*?)...and misleading...*a guide to North American Species*: fish are not covered at all, amphibians and reptiles are given a token amount of space (12 species, fewer than 3% of those in North America), birds (71 species, 10% of breeders) are allotted only a fraction of the coverage of mammals (143 species, one-third of known species), this despite the fact that the number of species of birds alone outnumbers those of mammals in North America. I do understand that there is very little variation in skulls amongst warblers or sparrows, for example, and illustrating each species could quickly become redundant. However, the mammalian bias is still overwhelming.

The mammalian dominance in this book is also reflected in the amount of text devoted to each species account – one *line* for each herp, one paragraph for each bird, four or more paragraphs for mammals. About 100 pages of measurement data are provided for mammals (which is wonderful), though none is provided for the others. One is forced to ask, "Why bother with the birds and herps at all?" The same amount of space could have been used to make a more complete book focussing on mammal skulls alone. Then, subsequent volumes addressing other taxa could complete the series.

I particularly liked the early chapters on interpreting form, marks on skulls (from gnaw marks to bullet holes) and preparing skulls. These chapters were informative and well-written. For me, a large part of the worthiness of this book was in these early chapters. That is not to diminish the worthiness of the mammalian species accounts, they too are thorough and instructive.

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A Field Guide to North Atlantic Wildlife

By N. Proctor and P. Lynch. 2006. Yale University Press P.O. Box 209040, New Haven, Connecticut 06520-9040 USA 221 pages. U.S. $19.95 Paper.

This book arrived on the morning I left for Svalbard in the Norwegian arctic. While the area covered by this book, offshore from North Carolina to Newfoundland, is some distance from Norway, the two areas do share a lot of wildlife. So I took the book along to make direct field comparisons.

I like the author's concept for this guide. He has selected the most likely species you have some possibility of seeing on a pelagic trip or ferry crossing in the northwestern Atlantic. This includes the large 'plankton' and algae, fish, turtles, whales, seals and seabirds. Only the more common species are included, enabling the authors to keep the book small [18 × 11 × 1.5 cm] and portable. This meant I was able to identify Beroe's Comb Jelly, Fin Whale and Ivory Gull carrying only one guide. The guide does not include coastal species such as crabs, molluscs and inshore fish.

The descriptions are well written. For example, the text for Fin Whale is a version of the classic descriptions found in many guides. I compared this to a whale that circled the ship and the information given was accurate down to the details of the back chevrons.

I had far more problems with the illustrations. First there is no attempt to show scale. A 10-inch flying fish is shown as the same size as an 18-inch species. This is a critical characteristic for look-alike species such as Glaucus and Iceland gulls. You need to check the text to see that there is a 5-inch difference in size. Similarly the Northern Seal plate shows the tiny 4 foot Ringed Seal as the same size as the 9 foot Hooded Seal. I found this disconcerting.

Some of the species shown are really cold water arctic animals. The North Atlantic is the southern fringe of their range. This is not mentioned for animals like Beluga, Dovekie or Harp Seal. I think giving their typical range would add perspective and could be said in few words.

The non-bird illustrations were very good. The artist has captured the short face of the Ringed Seal and the longer-nosed head of the Harp Seal very well. The fish portraits from the warm-water Dolphin [the fish] to the cold-water Cod are accurate.

The bird illustrations are another story. For example, the illustration of the Arctic Tern looks almost identical to that of the Common Tern. The Arctic has a shorter head and a longer tail giving it a different fore-and-aft look from the Common. The wing pattern is also quite different, having less black and giving the Arctic a much paler appearance. I had similar issues with other confusing pairs [Leach's and Wilson's storm-petrels, Glaucous and Iceland gulls, Audubon's and Manx shearwaters, etc.] Many other species lacked the subtle plumage differences that help confirm identification. For example, the two-toned grey on the wing of a Kittiwake and the armpit marks on the murres. Many birds are shown in winter plumage only. This is a reasonable approach as many birds disappear inland or north to breed. However, the winter Atlantic Puffin is very odd and the loon illustrations do not capture these birds at all well. It appeared that the artist did not have field experience with these species.

This is, however, a useful little book. If you are a novice I would recommend you take this book plus a modern bird guide on your pelagic trips. For more experienced bird watchers this book will suffice to remind you of the key points for what you may see and will be useful for all the non-bird species.

I thank Dr. Tom Smith, a fellow traveller, for sharing his immense knowledge of arctic wildlife, and thereby contributing to my review.

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A Complete Guide to Arctic Wildlife

By Richard Sale. 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 400 pages. $49.95 Paper.

This is a comprehensive field guide to the birds and mammals of the Arctic. Author Sale describes the ecology and people of the region along with some Arctic history. He cannot avoid discussing both climate change and the threat of pollution. Short chapters on geology, geography and biogeography set the background. These are followed by the main text: a field-guide style section on the Arctic's mammals and birds. The information provided covers identification, size, voice, distribution, diet, breeding and taxonomy. The guide is illustrated with photographs supported by some field-guide style plates. Each species has a range map showing their circumpolar ranges.

I am always delighted to find a book that shows birds and mammals from a bio-regional perspective. Last summer I saw eight Snow Geese on the west coast of Svalbard – an unusual sighting. When you look at the distribution of the birds it is not hard to see how their expanding population could spill over the now unfrozen ocean a short distance eastward. This kind of perspective is difficult to reach when you use guides based on a political boundary (birds of Europe, Russia etc.)

The author's first problem was the difficultly of defining the boundary of the Arctic. He uses, in my opinion, the most sane choice. He has taken the 10°C July

isotherm, modified by extreme winter temperatures. This still leaves out some areas that I think of as "Arctic" such as James Bay and its Polar Bears and the northwest coast of Alaska with Belugas and Yellow-billed Loons. This, perhaps, proves that nature will never entirely fit into our human need for definitions.

Following his definition, the author then chose the species to be included as arctic birds and mammals. Here I am a little perplexed. He has, for example included Carrion Crow but not Black-billed Magpie (which I have seen at 63°N). He has only an introductory mention of the Gray Jay, which ranges to the shores of the Arctic ocean. Tree Swallow is given an individual account while the more northerly Cliff Swallow (I have seen it at 73°N) is merely mentioned as a rarity. I am also confused by the species he has decided to split and those he leaves as sub-species. For, example he has Iceland and Thayer's gulls as separate species but not Mew and Common gulls. There seems to be better evidence to split the latter. Similarly you can question having separate entries for Black and Common scoters.

These are minor points and not as significant to my two major concerns. The species descriptions are detailed and clear and are some of the best I have read. While they are first rate, the author gives exceedingly spartan information on confusing species. This is in contrast to the descriptions, which often allude to an important field mark. For example, he states the three central tail feathers of the jaegers are "distinctive." In the field separating a Parasitic Jaeger with a 9 cm tail extension from a Long-tailed with a 12 cm extension is not that easy. I well remember a controversial bird that needed the late great Earl Godfrey's talents to resolve as a Long-tailed Jaeger. Similarly the information on the Common and Hoary redpolls is not enough for field separation. There is no mention, for example, of the stubby bill of the Hoary – very evident in the nice accompanying photo.

My second point is that this is not a complete guide to wildlife. Unlike such books as Les Beletsky and Dennis Paulson's *Ecotraveller's Wildlife Guide to Alaska* it does not contain any information on plants, insects, marine invertebrates and fish or amphibians. Admittedly Beletsky only includes the commoner, more visible species although his title does say it is a complete guide, but he does include a broad spectrum of the wildlife, other than birds and mammals, visible to the naked eye.

While this in not meant as a coffee table book the photographs are really eye-catching. The bird plates are quite good, but I was less taken with the mammal plates. My chief reservation about all these illustrations is they frequently show only adult males.

I will take this book with me on my upcoming trip to the Pribiloffs. For the most part I will be seeing wildlife that I am familiar with and I will not carry a conventional field guide to the birds or mammals. This book will provide me with more encyclopaedia-style information about the creatures I am seeing. I will also take Beletsky and Paulsen's book and a flower guide.

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The Black Flies (Simuliidae) of North America

By P. Adler, D. Currie, and D. Monty Wood. 2004. Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6 Canada, and Cornell University Press. 941 pages. $99.95 US.

This is a huge book. It is huge in size, filling 941 pages. It is huge in scope, treating the biology, management and identification of the entire black fly fauna of Canada, the United States, and Greenland. And it is huge intellectually, the culmination of many decades of work by an enthusiastic international community of researchers, among whom the authors of this book are prominent members.

In the preface, Peter Adler states that the book is "geared to a general readership." I would not have guessed that this was true, at first glance, but after some perusal it seemed to me that the book would be useful from about the undergraduate level on up. The writing is clear and precise, but the vocabulary will be daunting for most people without biological training. I suspect that the book will find a place in almost all scholarly libraries, and that the specialists who will use it most probably ordered a copy before it came into print. But there is a wider audience for the book as well, and in this regard I predict that it will be a required reference for many decades to come. The authors mention its relevance to medical and veterinary entomologists, aquatic biologists, environmental consultants, systematists, naturalists, pest management specialists and students, but I suspect the real list will be longer than that.

The text is arranged in four parts, covering background information, biology of black flies, economic concerns, and systematics and taxonomy. The first part provides an overview of the subject, a very readable history of the study of black flies (with lovely historical photographs) and a chapter on techniques for collecting and curating black fly specimens. As an entomologist (with no particular interest in black flies, I'll admit) I nonetheless found this section very interesting.

The second part of the book deals with the biology of black flies, and consists of a fine treatment of the structure of these insects (and their immature stages), as well as a well-written overview of their cytology. Black fly cytology was pioneered by the late Klaus Rothfels, a man deeply missed by the authors, and who they refer to as "friend, mentor, and phenomenon." A chapter summarizing the life history and behaviour

of black flies is also offered, along with an exhaustive summary of blood feeding host records, and records of black fly diseases and parasites.

For most readers, it is likely that the third part of the book, which treats the management of black fly pests, will be the most interesting. I can see this part of the book providing fodder for any number of term papers, research paper introductions, and consulting and government reports. I was surprised, however, to find that the chapter on management (Chapter 8) was largely historical in nature, without a summary of control recommendations. On careful reading, however, I could see the reason for this approach. Oil-based pesticides, DDT, and other chemical controls for black flies have not stood the test of time. The authors summarize the use of the bacterial toxin *Bti*, but give it only a qualified nod, with the caution that it too might lose its effectiveness over time. The chapter ends in an interesting discussion of repellants, and repellant clothing.

The fourth and final part of the book is clearly the section closest to the authors' own interests. It treats the 254 species of "North American" black flies, thoroughly. The focus is not simply on identification, it is also deeply phylogenetic, and includes a very careful evolutionary justification for each and every level of the classification. This is followed by a superb species by species treatment of the entire fauna. Significantly, there is additional information on the economic significance (if any) of each and every species, adding greatly to the summary in part three of the book.

As a non-specialist, I have to admit that the most impressive aspects of the book to me were the illustrations. They begin on page 436 (well before the halfway mark) and they are so masterfully executed that I couldn't help but come away thinking that there was something deeply beautiful and elegant about black flies, their larvae and pupae, and the fine details of their anatomy. More full-body illustrations of the adults would have been nice, but the overall sameness of the other life stages illustrated convinced me that side-by-side comparisons of the adults might not be all that useful. Maps follow the illustrations, and treat the United States and Canada on a county level, but they do not show Greenland. And, as one might expect in a book of this nature, the reference section and the indices are exhaustive.

This is a *magnum opus*, and a tremendous labour of love. It ranks, in my opinion, right up there with Holldobler and Wilson's *The Ants*. Having said that, it seems to me a shame that the book appears to have been presented as a somewhat impenetrable scholarly tome, without a showy slip cover, and with little or no fanfare for the "general readership" to which it was addressed. Don't be scared off by the size, or the complexity of this book. It is a masterwork, and if any aspect of your interests overlaps with the subject of black fly biology, do consider adding this fine volume to your library.

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Literature Cited:

Hölldobler, Bert, and **E. O. Wilson.** 1990. The ants. Belknap Press (Harvard University Press), Cambridge, Massachusetts. 732 pages.

Insects: Their Natural History and Diversity: With a Photographic Guide to Insects of Eastern North America

By Stephen A. Marshall. 2006. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 720 pages. CDN $95. Hardcover

It has always been said that you can't judge a book by its cover, but after reading *Insects: Their Natural History and Diversity* I've learned that this well-worn idiom isn't always true. When this book first crossed my desk, to say that I was instantly enamoured would be an under-statement. It was so beautiful, the cover adorned with a stunning jewel-toned dogbane beetle (*Chrysochus auratus*). I almost didn't want to crack the binding. However, my curiosity finally got the better of me and I'm glad it did because once I started reading I couldn't put the book down.

Visually stunning, with over 4000 colour photographs of insects in their natural habitats, *Insects: Their Natural History and Diversity* has the look and feel of a glossy coffee table book while still being full of accurate, well researched information.

As its title implies, *Insects: Their Natural History and Diversity* focuses on the diversity and natural history of common families of northeastern North American insects. The book opens with a brief synopsis of basic insect anatomy and morphology. This is followed by chapters covering the diversity of all insect orders, including all the major families, along with two chapters on non-insect arthropods and methods for observing, collecting and photographing insects. The book's last 50 pages are dedicated to illustrated keys to order and family as well as a key to the most commonly encountered insect larvae. These keys are designed to facilitate ease of use and therefore emphasize morphological characters visible to the naked eye or easily seen with a hand lens. Also peppered throughout the book are helpful suggestions on where to look for and find various insect orders/families. For example, "Depending on your inclination and the weather, a good place to start looking for assassin bugs would be in your kitchen light fixture. Unless you are much more

fastidious than most, the odds are that among the crispy critters accumulated there you will find a large black assassin bug called the Masked Bed Bug Hunter (*Reduvius personatus*)."

Considering that *Insects: Their Natural History and Diversity* is priced so as not to be cost prohibitive and is clearly written in plain language, it will be highly accessible to a broad audience, including naturalists, amateur entomologists as well as seasoned professionals. The author has also included a dollop of humour and wit throughout the text. For example, this passage describing the appearance of springtails: "Some are covered with scales, like those of a butterfly, many are brilliantly colored and all are morphologically bizarre, starting from the long, forked tail used to make Herculean leaps, and ending with the deeply pocketed mouth that makes springtails look like they have lost their dentures and then sucked on a bunch of lemons."

This book would make a great textbook for a natural history or general entomology course. Especially when you consider that the impetus for this book centres on materials originally gathered in support of the author's third-year course "The Natural History of Insects" at the University of Guelph. With its depth of scope and true to life colour photographs *Insects: Their Natural History and Diversity* would be indispensable in the field; however due to its size, it would be a bit unruly to have to lug around.

I thoroughly enjoyed this book and would recommend it whole-heartedly to anyone who has an interest in entomology, natural history or a simple curiosity about the six-legged world that surrounds us.

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The Northern Goshawk: A Technical Assessment of its Status, Ecology and Management

By Micheal L. Morrison. 2006. Cooper Ornithological Society, Pennsylvannia.

The Northern Goshawk: A Technical Assessment of Its Status, Ecology and Management, is just as the title suggests, a highly technical assessment of the goshawk. I do not recommend it to those looking for a light read. Micheal L. Morris, editor, has compiled 22 recent journal articles that study the Northern Goshawk, focussing on ecology and population. Morris outlines two objectives for the assessment; the first is to summarize existing knowledge of the goshawk into one book, and the other is try to provide a framework for the development of future regional conservation and management strategies for the species.

Due to the legal issues surrounding the Northern Goshawk and its proposed listing as a *Species at Risk*, particularly in the United States, this book is a useful step for establishing what we do and what we do not know about this Accipiter. Unfortunately, it appears that the latter predominates.

Morris structures this assessment in an appropriate way, starting with an article that extensively covers the ecology of the goshawk, which helps provide the reader with a general knowledge of the bird. After this first article, the volume is divided into three distinct sections: Regional, Ecology, and Management, each of which contains a number of independent studies that Morris has gathered from several sources. Each of these studies take a highly regionally specific look at certain aspects of the Northern Goshawk. The goshawk has an extensive range over North America, Europe and Asia. As a result of this huge regional coverage there is extensive continental/regional variation amongst populations of these birds. This makes it difficult as a reader to distil any major trends between the articles. I found it hard to link many of the articles together because of the different styles by which the studies were carried out, as well as some differences of opinion. For example, Squires and Kennedy suggest that "[impacts from forest management] can either enhance or degrade goshawk habitat depending on type and extent of habitat alterations" (page 61). This is not so much a weakness of the assessment but rather the reality of goshawk management, and emphasizes the need for regional management strategies instead of an all encompassing global strategy, which is one of Morris's initial goals for the assessment.

Overall, this publication is a building block. It establishes where we have been in terms of goshawk management and conservation and makes clear where we need to head in the future. Morris has done a good job of selecting appropriate articles that clearly depict the challenges faced by researchers and the Northern Goshawk. I would recommend this book only to those who want to critically study goshawk ecology.

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Turtles of the World

By Franck Bonin, Bernard Devaux, and Alain Dupré (Translated by Peter C.H. Pritchard). 2006. Johns Hopkins University Press. 416 pages. Illus., $50 (US).

First published in 1996 in French, this guide to the turtles of the world has been translated into English by eminent turtle biologist Peter Pritchard. In the translator's note, Pritchard acknowledges that he has also made some corrections and updates to the text. As such, the book includes recently discovered species such as *Pelusios cupulatta*, only described in 2003.

The book is divided into two sections: General Biology and Identification. General Biology provides a brief (nine pages) overview of the evolutionary history of turtles, their biology and conservation issues. Identification provides information on the approximately 330 recognized species of turtles. The species are grouped by families within the two suborders Pleurodira and Cryptodira. In general, each species account follows the same standardized format: distribution, description, natural history, protection. The species accounts vary from about half a page to three pages in length.

Each species also has a small regional map showing which part of the world the species occurs in and a larger, close-up map showing the distribution as shaded areas. These distribution maps also show major river systems, as well as some political boundaries. In addition, almost every species has one or more colour photographs.

Any attempt to list the names of all the species in the world of a certain group is a daunting task of sorting out sometimes conflicting and constantly changing taxonomy. The authors have accepted the recent splitting of the genus *Clemmys* and duly note this change in the appropriate species accounts. In contrast, the entire genus *Sternotherus* has been subsumed within *Kinosternon* without any explanation. While there has been debate over the validity of *Sternotherus* as a distinct genus, lumping the two genera goes against the current standard North American taxonomy. The authors are also somewhat inconsistent in assigning species status. They do not provide species accounts for *Chelodina mccordi* or *C. pritchardi* (although they are mentioned under the species account for *C. novaeguineae*), yet both these species are widely accepted. On the other hand, they elevate *Hardella indi*, a subspecies of *H. thurjii*, to full species status without any justification. This may explain why *Hardella indi* has the shortest species account in the book – three sentences.

There are some strange oversights in this book. The IUCN Red List of Threatened Species is the standard international ranking system for species at risk of becoming extinct. It designates status for these species from Lower Risk up to Critically Endangered. *Turtles of the World* occasionally mentions if a species has been "red listed," but not consistently, even within the same genus. For example, all four species within the genus *Acanthochelys* are on the Red List, yet the species accounts mention this for only one of the species. The book says one of the other species is on the "IUCN priority list" and the "IUCN is worried" about another. None of the species accounts provides the IUCN status, so the reader will not learn that *A. pallidipectoris* is considered the most endangered of the four species.

A thorough reference section is also lacking. The references for this book do not even fill two pages and almost all of the references are to other books on turtles. Accordingly, most of the information in the book is presented without any reference to a specific primary source. However, occasionally a statement is referenced and in almost every case that reference is absent from the reference section.

Of the Canadian species, the map for *Graptemys geographica* (Common Map Turtle) excludes the Ottawa area and all of the Quebec part of the range, and maps for both *Glyptemys insculpta* (Wood Turtle) and *Emydoidea blandingii* (Blanding's Turtle) omit Nova Scotia. *Terrapene carolina* (Eastern Box Turtle), a species never confirmed to have been historically present in Canada at all, is shown as ranging across all of southern Ontario as far north as Toronto. The range is also over-extended in Michigan, Ohio, Pennsylvania and New York.

Despite these criticisms this is a significant book in turtle biology. The photographs are often excellent. The natural history section, while sometimes too short, provides insight into an incredible variety of life history strategies. For many species, the contents of the protection section provide important information on threats, as well as a wide diversity of conservation measures. This volume is not the definitive statement on any of these 300+ species but it is a good introduction to the diversity of turtles.

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The Wolves of Algonquin Park: A 12-year Ecological Study

By John B. Theberge and Mary T. Theberge. Department of Geography, University of Waterloo, Waterloo, Ontario N2L 3G1 Canada. 163 pages. Available from bkevans@fes.uwaterloo.ca. $23.50 Canadian, $20 U.S.

John and Mary Theberge, a husband and wife team, have put together information available on wolves and their prey in one of North America's great ecosystems. Research results from the twelve year period (1987-1999) was used as a core for the publication. Student projects were as follows: 1 Ph.D. thesis, 7 MSc. theses, 11 BSc. theses). Overall, scientific publication of 55 papers is impressive. In the end, it was the Theberge's that pulled the material together into this single monograph. For that they need to be congratulated.

The results of the study are also based on previous work begun in the 1960s. The Theberges reached back in time and reanalyzed and re-evaluated some of the data collected earlier. A major portion of the review centred on the taxonomic study of Wolves in the park. They concluded that these canids were larger than the Coyote-Wolf hybrids to the southwest, smaller than wolves to the northwest. It reinforced earlier conclusions of the existence of "Algonquin type", "tweed type" and "boreal type" Wolves. New is the interpretation that these Wolves are taxonomically connected to the Red Wolf taxon, once more common on the continent to the southeast. In the "canid soup of genetics" these are many theories and assertions. So far there have been no clear indications of the "ultimate" position. Maybe none will ever emerge that will satisfy everyone who is interested in the subject. The Theberges have presented a convincing case.

Other portions of the monograph are equally well presented. There is much in the way of natural history – basic insight into the ecology of the predator within the prey dynamics dictated by geographical and botanical (habitat) setting. In an age of computers, abstract analysis and spurious mathematical modelling, this work stands out as a major contribution to science. It combines solid field work with a realistic quantitative assessment of the results, and I would recommend this as a case study for first-year graduate students who are contemplating a career in wildlife research. Beyond that, the study has had a real impact on conservation. In 2001, a total year-round Wolf killing ban in areas bordering Algonquin Park was announced by provincial authorities. Political responses were based on research results. It is a rare occurrence that this happens and it is a response to the well executed research. By any standard, that is a remarkable outcome to many years of dedicated work by scientists whose meticulous research and commitment to science were also coupled to a dedication to conservation and to bioethics. This is a scholarly monograph that likely will not be surpassed for many years to come.

At the outset the Theberges posed a series of questions that they wanted to find answers to. Likely some were listed after the fact, when intensive research results came in from the field work and data analysis. That too has strength. I cannot see much that has been left out. Appropriate photos and illustrations are found throughout the text. Some questions arose in my mind as to alternate explanations for some of the conclusions reached. Such results are inevitable and provide a useful basis for future scholars. This monograph is an exceptional document and has set a very high standard. I highly recommend it to anyone just starting field research on mammals, or for those veterans, who have spent much of their time in the pursuit of knowledge in the field of wildlife science.

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BOTANY

Flowers – How They Changed the World

By William C. Burger. 2006. Prometheus Books, 59 John Glen Drive, Amherst, New York. 14228-2197 USA. 337 pages. US $23.00. Cloth.

Why are flowers important? They are not just for the viewing pleasure of humans, although they are spectacular – but why? This book will answer these questions. "Without the gift of flowers … man might still be a nocturnal insectivore gnawing a roach in the dark." It is often true that the more we know about something the more we appreciate it and the more we enjoy it. A book that leads to enjoyment is worthwhile, but this book also provides a much needed perspective on the flowering plants at a time when the world faces a biodiversity crisis. It contributes to an improved understanding of the natural world and a concern for the future. It is a very valuable contribution as well as a very enjoyable book that will appeal to anyone as a result of the friendly writing style.

William Burger, curator emeritus in the Department of Botany at Chicago's Field Museum, takes us on a journey to the discovery of how flowering plants have transformed the world. He begins with "What exactly is a flower?" which is a delightful and comprehensive introduction to flower morphology or what makes a flower a flower. Floral parts and their role are described in different kinds of flowers. It comes as a surprise to many people that the four bright white petals of a dogwood flower are not petals and the flower is actually an

aggregation of many flowers, that a dandelion flower is made up of dozens of flowers, that grasses do have very special flowers with floral parts analogous to those of tulips.

The book is full of fascinating anecdotes. Why are Wolves friends of plants? By 1926 Wolves had been extirpated in Yellowstone and Yogi, Booboo, and the other bears were of course more interested in picnic baskets than controlling the Elk so there were soon too many Elk and the vegetation began to change. Seventy-five thousand Elk were removed between 1926 and 1968 but it was not enough to get things back to the way they were – although it did maintain some plant diversity and kept the park green! Finally, in 1995 a human brain triumphed and thirty-one Wolves were reintroduced to Yellowstone and that quickly got things back to the way they were. There was less browsing pressure as "fear factor" came into play with Elk avoiding places where they were more likely to be ambushed by Wolves. Browsing was not only reduced, it was spatially variable, creating more niches for plants. The entire Chapter 2 is a very entertaining voyage though the annals of ecology indicating how plants are assisted and influenced by other organisms.

Flowering plants have a vast array of enemies, the herbivores, which are everything that eats plants, but they have developed chemical and mechanical defences. This is the subject of Chapter 3 "flowers and their enemies." It is full of the interesting stories that are known well to biologists but not to others – such as the central American Acacias that have a police force of stinging ants that emerge from the hollow thorns to attack intruders but also destroy the surrounding vegetation that competes with the Acacia. This is a mutually beneficial relationship. As well as a home in hollow thorns the ants are supplied protein by specialized leaf glands and sugar from other glands on the Acacia stems.

Chapter 5 "how are flowering plants distinguished" outlines the evolution of the distinctive features including tissues adapted to prevent water loss and to allow transport of water and nutrients and particularly the seed; which allowed land plants to achieve reproduction without external water, unlike ferns and frogs. Did you know that the simple, 120 million-year-old flower of *Archaefructus* has cast some suspicion on the evolution of flowers by reduction from Magnolia-like ancestors (contrary to what we told and regurgitated for the final exam a *few* years ago). The classification system, double fertilization and the evolution of fruit and many other complex phenomena are introduced in a clear and very interesting way. There is a wealth of information in this chapter and although it may be the most tedious chapter in the book, if you want to know what a plant is all about, you will not find a better general presentation of this information.

Chapter 6, "what makes flowering plants so special?" points out that flowering plants were not present in the forests of 300 million years ago (that made coal) but appeared 120 million years ago, were apparently little affected by the great extinction that wiped out the dinosaurs and other lineages, and became 87% of all plants today. The estimated 100-fold increase in the number of plant species since the Carboniferous period is mostly a result of the proliferation of flowering plants. The chapter explains why they are so successful and special in sustaining 99% of life on the planet. It may seem strange to find an explanation of photosynthesis in the same chapter as an explanation for the similarity of the floras of eastern North America and Japan, but the reader is definitely left with an idea of how special flowering plants are.

With the excellent introduction in these chapters the reader has developed a comprehensive knowledge of botany and ecology which provides a basis for the last two chapters, which indicate how flowering plants changed the world. Chapter 7, "primates, people and the flowering plants" explains how flowering plants created a world in which humans could live. The nectar, pollen, foliage and fruits together set the stage for a proliferation of insects and this led to the evolution of many new groups of insect eaters including the earliest primates, – but how did flatter faces, dextrous digits, upright stance and larger brains develop? It is all here. The chapter concludes with an explanation of how flowering plants and people came together to develop agriculture and how major civilizations rely upon flowering plants.

Of course flowering plants did not just create a world for humans, they also changed the world in many other ways and this is dealt with in Chapter 8, "how flowers changed the world." As they vastly increased in numbers they increased overall biodiversity. Biochemical specialization is explained with fascinating examples. Effect on the weather is considered including gradual cooling through carbon sequestration and the effect of grassland expansion. The chapter concludes with an outline of the effect of human actions on flowering plants and their impact on the world. An epilogue outlines the responsibility of humans with regard to protecting and managing plant diversity and preserving the world.

Following the epilogue is a series of notes 17 pages in length providing additional information sources for each chapter. This is an extremely useful section, vastly improving the educational value of the work, and it serves as an indication of the very extensive knowledge of the author. The book also has a colour insert of 12 attractive plates. It concludes with a very useful glossary that defines terms such as carpel, caryopsis and cleistogamous. The index is very helpful.

Burger's book is definitely a journey. It pulls together a broad array of concepts into a developing theme of how flowering plants got us to where we are today. It offers a biological perspective including the basics

of botany, ecology and evolution combined into a picture of plants and people and ends with an evaluation of where we are and where we are going. If everyone read and understood this book – if everyone had the knowledge and the respect for life and the inquiring and sensitive mind of its author – we would be in a better position to save the world.

This book is an example of outstanding communication. It provides biologists with what they need to know to teach, but it is not just for the biologist, nor just for Americans who spend nineteen billion dollars annually on leisure-time activities related to flowers and plants – it is for anyone. Behind the provocative title is a beautifully written book describing what flowering plants are, how they have influenced the evolution of life, contributed to the origin of humans and enabled humans to become the masters of our planet with the responsibility to manage its resources properly. It is so far from being just another book!

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ENVIRONMENT

Guide to Deserts

By Andrew Warren and Tony Allan (General Editors). 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 240 pages. $19.95 Paper.

After reading this book I realised I have never been to "see" a desert. I searched for Scimitar-horned Oryx (northern Sahara). I marvelled at the marine life off the Peruvian-Chilean coast (Sechura-Atacama desert). I have visited the impressive Abu Simbel temples (Libyan desert). But I have not really looked at the desert for its own sake. This is a mistake I will not repeat. While I have not been completely unobservant there are many subtleties I have missed. In future I will look for zengens, desert pavement, inselbergs and yardangs.

Deserts is a neat, small book in which the author defines deserts and describes the climatic conditions that shape their landscapes. He gives examples of the different types of desert and illustrates the impact wind and – yes – water have had on the land and its inhabitants. There are six chapters on aspects of deserts and an atlas of the major desert areas. The chapters cover wildlife such as plants, invertebrates and mammals and how they are adapted to thrive in an arid ecosystem. The people of the desert, their food, clothes, homes, customs and religions are described. This is an important chapter with the current focus of news from the deserts of Badiyat Ash Sham (Iraq) and Dasht-E-Margow (Afghanistan). The authors explain the riches of the desert. Not just oil, but farming and mining. They also look at conservation issues and the damage done by human activity. After reading this material I am more convinced we need to re-assess the use of water for irrigation.

The atlas is really a field guide of the world's 14 major arid zones [Canada's minuscule desert in British Columbia is not mentioned]. In addition to a map there are descriptions of each area's key characteristics. This includes some history, the people and key issues as well as a physical description. The authors have written a special chapter on visiting deserts to encourage people to see these special places.

There are plenty of photos and illustrations. These have been chosen not so much as pretty pictures, but to illustrate the points in the text. They range from the stark beauty of Monument Valley, through the rock-cut ruins at Petra to simple depictions of dunes. They show the faces and costumes of Tuareg, Berber and Bedouin (but not Navajo or Apache). The author has not missed mine sites, luxury hotels or aerial views in making his selection. One photo supposedly containing Giraffe, Ostriches and Eland shows six Oryx, some distant gazelles (presumably Springbock) but no Eland.

This book is very interesting to read just because it puts deserts in perspective. For someone like me who goes to places looking for something special, this book gives added value to a trip. For all of us it gives a wonderful background on where desert's ecosystem fits in the world's biosphere. The authors have convinced me that deserts are important and I will pay more attention in the future. Buy this book for yourself.

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Endangered: Wildlife on the Brink of Extinction

By George C. McGavin. 2006. Firefly Books Ltd. 192 pages. U.S. $35.00 Cloth

An ecologist could not help but be drawn to a book with the title *Endangered. Wildlife on the brink of Extinction*. seeking an update on the current state of the world's species at risk. Unfortunately McGavin's book does not provide a succinct analysis of current status, the impacts we should be most concerned about, geographic localities of concern and the likely future trends. Rather this coffee table book provides a piecemeal of "information bites" for fifty animal groups ranging from dogs and cats to salmon and songbirds.

The lengthy (50 of 192 pages) two chapter introduction on the "Nature of Extinction" and "The Sixth Extinction" could be a grade nine biology course covering the basics of evolution and human development from our hunter-gather roots, through our agrarian and industrial revolutions to an assessment of supply and demand harvesting of nature. Instead of a discussion of the ecological implications of the loss of species to ecosystem integrity, extinction is considered more in terms of the extent of human mourning and the likely curiosity of future generations about species that once existed.

The "Lost and the Last" chapter constitutes the central text starting with Monotremes and Marsupials. Typical treatment of species groups include general statements such as: "Platypus eggs are eaten by introduced red foxes and rats as well as by native predators such as lizards. Many echidna eggs suffer the same fate." This text provides no meaningful information on the status of even these most unique of creatures for which clear trends must surely be known. No consistent format is used to cover each animal group, for example within the sub-section Insectivores Insectivora the subtitles used could have been chosen at random: Sense of Smell; Desmans in Danger; Desert Moles; Rare and Restricted; and Solendon Capture. Often the information presented begs the question; What has this to do with wildlife on the brink of extinction? If general ecological information is to be presented it would have been better in a text box or sidebar as a special case study.

Much more information could have been conveyed by following a consistent format for each animal group with sub-headings that allowed the reader to move from one group to another building an understanding of the most threatened species, the number of species threatened within each group, the ecological implications of species loss, the key causes of species decline, likely future trends and actions required to reverse negative trends. Summary graphs, tables or pictorial representations are virtually absent, yet they too could have been used to convey large amounts of information in a simple repeatable format for each species group.

The most impressive aspect of *Endangered* is surely the figures but, while there are captions, the text makes no direct reference to the figures and text and figures are often unrelated. In the Prosimians group the text states: "The strangest prosimian is surely the aye-aye. Its wide eyes, pointed ears and thin bony fingers lend it a goblin-like appearance". No picture of the aye-aye is included, but pictures of the sifaka and loris are included with no information on their status.

There is considerable variability in the treatment of each species group with some written in a more authoritative style, Bats Chiroptera is one example where there is a logical organization of sub-sections and more information on extinction. Variability is also seen in how comprehensively each species group is covered and this appears unrelated to the extent of information likely available. For example, the monkeys species group includes less than one page of text while the amphibians group has four pages of text.

In summary, *Extinction* provides an enormous amount of anecdotal information that is interesting to read, but which is likely forgotten soon after having read it. The book leaves the reader with a sense of disaster for all creatures as a result of human activity (which may or may not be far off the truth) and attempts to deal with all the ills of humankind from switching off light bulbs to buying local produce. Unfortunately readers that might be inclined to read *Endangered* will likely come away knowing little more than they started with.

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MISCELLANEOUS

The Reluctant Mr. Darwin: An Intimate Portrait of Charles Darwin and the Making of His Theory of Evolution

By David Quammen. 2006. Atlas Books/ W. W. Norton & Company, New York. 304 pages. $30.00 Cloth.

As naturalists, we never cease to be amazed by the myriad wonderful life forms in nature, be it the flowering plants that suddenly appear following snowmelt, the wide variety of birds that return north every spring, or the colourful mushrooms found each fall in our forests. However, the source of this very diversity may easily be perplexing: why are there so many species and how did they originate? The theory of evolution has gone a long way towards explaining these and related questions by means of a wealth of empirical and theoretical studies.

Evolution by natural selection as [formulated] proposed by Charles Darwin is one of the most important and far-reaching ideas ever formulated, as it provides the basic mechanism whereby evolution has created the enormous diversity of life. David Quammen's objectives with his book were to offer a concise yet insightful overview of the background, birth and development of Darwin's idea of natural selection, and to consider the reasons for Darwin's reluctance in making his theory public. Indeed, there were many reasons why Darwin might have wanted to keep his evolutionary views to himself. These included the fear of rejection from a science corps whose natural history was based largely on teleological ideals with foundations in religious agendas, as well as his personal relationship with his beloved wife Emma, a pious Christian. In the end, it was Darwin's receipt of a manuscript from Alfred Russel Wallace, who at the time was collecting beautiful bird and insect specimens somewhere in the Malay Archipelago, which prompted the eventual publication of *On The Origin of Species* in 1859.

Quammen outlines this momentous piece of history concisely and does not attempt to compete with other more exhaustive biographies that provide a more detailed and scholarly account of Darwin's idea. The result is a very readable book that, despite the fact that Quammen is not an academic scientist, is based on thorough research of original background material. Hence, this book follows in the tradition of Quammen's previous successes, most notably *The Song of the Dodo* (1996), his outstanding and award winning volume on island biogeography. Several interesting aspects of Darwin's life are also highlighted, such as his mysterious illness, characterized by dizziness, stomach pain, and bouts of illness, often flaring up under stressful conditions. Darwin spent weeks on end at health clinics, surrendering his body to coldwater treatments, hoping to rid himself of the persistent ailment. The book also describes a number of the small natural history experiments that Darwin performed to understand the mechanisms of evolution, such as submerging common vegetable seeds in brine solution to investigate the possibility of over water dispersal, or dangling duck feet in water to see if gastropods would climb aboard on a flight destined for other ponds. With these sorts of amusing passages highlighting the development of the most important idea in biology, *The Reluctant Mr. Darwin* should be of great interest to naturalists regardless of whether they are deeply aware of evolutionary theory or simply familiar with Darwin's work. The good quality of the material in this volume, along with Quammen's command of the English language, makes this book well worth the read.

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A Field Guide to Gold, Gemstones & Mineral Sites of British Columbia, Sites Within a Day's Drive of Vancouver

By Rick Hudson. 2006. Volume 2. Revised Edition. Harbour Publishing Co. Ltd., P.O. Box 219, Madeira Park, British Columbia VON 2H0 Canada. 368 pages. 8 illustrations $16.95 CAD

Rick Hudson has succeeded in expressing his passion for mineral collecting through his field guide book. On a second level he also tries to promote a sense of adventure by teasing the reader to go out and explore or prospect for nature's buried treasures.

The author structured the book so the reader can easily cross-reference required information in the lengthy location lists. A "How to Use This Book" and a "Quick Reference Guide" help to quickly locate items of interest throughout the book.

The book cover illustrates the hobby of mineral collecting as a family activity. Hudson educates the reader from first principles on how to become a Rockhound. To accomplish this, he describes how to prepare yourself by choosing proper clothing, safety gear, collecting tools and maps. He warns the future mineral collector about natural hazards they may encounter such as; rattlesnakes, grizzly bears and ticks. Ethics, access rights and mineral rights are also discussed to keep the collector within acceptable collecting practices and to avoid unintentional trespassing.

Mineral collecting is attractive to many people because as you find an interesting mineral specimen, you want to learn how nature created it and or its geological history. The author included short geological descriptions partitioned by collecting areas as well as mining histories of local economic importance within the collecting area.

Colour plates illustrate the minerals found in some of the collecting sites and detailed occurrence maps are included in all the collecting area sections throughout the book. The colour plates represent minerals that are possible to find in the collecting sites. Government mineral index files were included in the locality information along with detailed road log descriptions.

The author has made a successful merger of personal knowledge and technical data to compile an informative volume which can provide years of enjoyment for many future rockhounds and their families and friends.

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History of the Russian Zapovedniks 1985-1995

By F. Shtilmark. (Translated from Russian by G. H. Harper). 2003. Russian Nature Press (www.rusnatpress.org.uk). 307 pages, £30.95

This book makes a major contribution to the environmental history of Russia, its influence zone and also to the global nature heritage. The Zapovedniks - Russia's protected nature reserve system – have withstood the test of time, although it has been distorted by social and political factors. Due to the great English translation by G. H. Harper, the Russian Nature Press offers us new views on conservation, as well as solutions to the current problems with protected areas world-wide. The original text is written by one of the leading Russian environmental writers and fascinatingly energetic activists providing for superb inside knowledge unknown to the western world. His visions are guided by principles such as "we have a duty to make our zapovedniks and national parks the pride of Russia...".

In this great book the reader will learn about Russia's nature, and foremost, about how to protect it during such fascinating and complex times like Tsarism, the rules of Lenin and Stalin, and Gorbachovs' glasnost and perestroika (the book manuscript was finished 1996). Throughout the history of the Zapovedniks (in short called Zap's) the role of the Academy of Science proves very significant. The composition and attitude of its board members towards protection vs. exploitation play a crucial role for Zap-Management (and species survival).

Most readers will likely be surprised to learn that the Russian Zapovednik system actually acted as a model for setting up the global network of biosphere reserves. But to this very day there exists a fundamental confusion in the western world regarding the terminology and meaning of Russian protected nature reserves. As described over the 307 pages, western-style National Parks represent only one component in the complex Russian system of Zapodniks, Zapovednosts, Zapovednayes and Zakazniks. A critical view of the author refers to National Parks simply as pseudo-zapovedniks because "An absolute Zapovednik is an area of land or water that together with all products of nature on and in it (plants, animals, soils, rocks, minerals) is preserved in perpetuity and in a state of inviolability".

Many Zapovednys were originally used for the Tsars or as a prince's hunting estate, e.g., the famous Kuban Hunting Reserve. So originally, these systems go back to land grants from the aristocrats. But the author takes great care in explaining that Qualified Zapovedniks have a weaker definition in their protection status, allowing for human use. A Zapovednost implies the complete withdrawal of an area of land from any economic use. The biological theory of Zapovednosts rests on the idea of an ecological equilibrium, and the capacity of organisms to regulate themselves in the absence of direct human influence. Zapovedaniye means a withdrawal of a certain area of nature from the sphere of ordinary economic activity for the attainment of particular non-traditional economic, social and ecological purposes. It represents samples of "virgin nature selected for comparison with exploited land". Zapovedny Management relates to a method of managing protected territories and water bodies. Further, one can find Zapovednik Museums, as well as Game Zapovedniks and even Spa-Zapovedniks. Only the Zakazniks are areas set aside for hunting. Finally, the Etalons are protected areas, model examples, representative for a specific ecosystem type and completely free from human influence.

Several black/white maps, portraits, tables and diagrams are presented, and including with some painted Russian scenery, turn this publication into a precious book to own.

The book makes a nice case that fur-bearing animals were considered as Russia's "Soft Gold"; they were one of the chief resources for foreign income. This wealth created the influential Moscow Fur Institute. Besides the earlier over-exploitation of Russian beaver resources, the 20th century showed also a sharp decline of sable, and a subsequent nation-wide harvest moratorium was not really effective. Therefore, sable reserves were requested, and a Sable Zakaznik was set up by local people in Kamchatka as early as 1882. These Game Zapovedniks were called Superior Zapovedniks in which hunting was not allowed, and breeding programs were initiated.

As elsewhere in the world, the tensions around protected areas were intense. Borders of Zapovedniks were often not followed or defined even. Poaching was common in taiga Zapovedniks or where "old believers", Chinese bandits, and fur-traders lived. In Crimea and elsewhere, the designated Zap-guards and zoo-staff were tortured or even executed.

Besides the many day to day struggles in Zapovedniks, Lenin's revolution then had a massive restructuring in place for them, resulting in the "Socialisation of the Land". It converted the entire country in a gigantic "national park"; ownership rights were removed with one stroke. Lenin was a hunter himself and had a great interest in nature affairs. That proved to be fortunate for Russia's nature, as well as for some aspects of the global environment. From that point on, the Russian Soviet Federal Socialist Republic (RSFSR, founded 25th October 1917) played a crucial role in the protected areas, and started its well known enthusiasm for regulations.

Some Russian Zapovednik administrators used the guiding principle "Nature is not a cathedral, but a workshop". And typical Zapovednik tasks dealt with the introduction ("Acclimatisation") and control of animal populations. Culling was part of most Zapovedniks,

and the culled game meat was contributed to the social food-supply or else was sold to Zapovednik staff. The elimination of crows, and cormorants as fish-eating birds took place Russia-wide. Bears, marten, gulls, skuas, crows, hawks and eagles got killed *en masse*. Extensive campaigns against wolves by poison and air were carried out for almost a century shaping the Russian culture against predators to this very day.

The text reads like a crime story. As felt in many other places in the world, the Stalinist revolution further led to more and major changes. Namely, a shift from nature protection to exploitation in the interest of the socialist construction. Protecting nature for the sake of nature was not *en vogue* anymore. Further, "Bourgeois" professors who comprised a large proportion of the conservation's cadre in the Soviet state in the 1930s were eliminated, and many members of the Academy of Science got arrested. From then on, Zapovedniks were explored for minerals, coal and oil deposits, timber resources and fur bearing resources, culminating in slogans like "We must take the Urals apart". The fetish of inviolability as a bourgeois theory got sacrified. Protection was now defined as exploitation. Under comrade Stalin, Zapovedniks turned into multi-purpose economic enterprises. It led to the view that planned exploitation of Natural Resources would be the main pre-condition of Nature Protection.

From the 1960s onwards the Zapovednik system experienced a modernization. A. G. Bannikov and G. P. Dementev started to participate in the IUCN. Russian-Japanese international migratory bird conventions got signed. In 1970-71 the UNESCO biosphere reserves "Man and Biosphere" were established. In 1972 a U.S.-Russian agreement on protecting the natural environment got accomplished, and the USSR Red Data book came into place.

As early as 1975 multidisciplinary monitoring was demanded in Russia, a theme that is very relevant for today even, and not achieved by most countries yet. When cheap fuel got provided for that purpose to the Zapovedniks by the state, they got quickly swamped with motorboats, snow tractors and motorcycles. Helicopters can be added to the list as well since flying was very common by then. The author explains that caterpillars tracked and wheeled cross-country, and vehicles ploughed up the tundra on Vrangel and Taymyr.

In the 1990s, the U.S. American Soros and MacArthur Foundations with their foreign funds gained considerable influence over Russia's nature; WWF, Evraziya, the Japanese Society for the Protection of Birds, the Global Ecological Facility, and the International Bank for Reconstruction & Development were other international players accounting for as much as one quarter of Western money on the expenditure for protecting Russia's biodiversity. This foreign influence made many Russian politicians extremely uneasy.

However, despite all of these gigantic efforts, and similar to the case in North America, nothing remains of the many original habitats such as the steppe. "We now need to introduce the specially-protected areas system almost forcibly to counterbalance irrational natural-resource-use, and to prevent deterioration of landscapes and valuable sites".

It becomes clear from the text that Russia and its Zapovedniks etc. are not set up for the information society at all, and thus Russian high quality online (raw) data are hard to come by still. Much crucial biodiversity information is published though in hardcopy and journals, or exists in filing cabinets, private ownerships and cabinets, and as expert knowledge. Otherwise, check the Russian Conservation News found online www.russianconservation.org.

One cannot find a better and centralized overview of Russian conservation history issues than this book; its detailed Appendices are further assets consisting of current and former Zapovednik lists, a Kyrillic reference list and in-depth annotations for each chapter. I find that this book is a little too friendly on the widespread view in Russia that traditional Zapovednik management caters primarily to the Russian race but leaves natives and other ethnical groups out. Marine protected areas were apparently not really part of Russia's nature protection system either.

However, "Come back in hundred years, then let's talk" (And in the meantime, I highly suggest buying and reading this important book).

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A Field Guide to the Identification of Pebbles

By E. Van der Flier-Keller. 2007. Harbour Publishing, Box 219 Madeira Park, British Columbia V0N 2H0 Canada. 9 inch by 8 inch pamphlet, $7.95

Professor Van der Flier-Keller has produced a neat pebble guide for children. She has condensed fundamental pebble geology into a single page. Then she portrays 34 types of rock as they appear when they are transformed into pebbles. She adds in a few man-made objects that also appear on beaches, such as glass. The pamphlet is a single long sheet of plasticized paper with clear, "life" size photographs of pebbles. It is easy to use and is ideal for children as it does not get over-complicated and therefore overwhelming. For example, it only shows two forms of granite – pink and white. This is quite sufficient for an 8-year old to absorb. While the author has reduced the text to a simple explanation she does use the correct technical terms throughout. Younger children may need help with some of the terms (plutonic) or concepts (glacial deposits), but then this is what parents are for. The pamphlet folds

to 4.75 inches by 9 inches and can readily slip into a pocket or glove compartment.

Although aimed at children this is a useful tool for the non-geologist adult who does not have the time (or inclination) to master the complex technology of geological science. I have a habit of picking up small rocks and pebbles from the places I visit. I have not been consistent in identifying them, but I am sure this pamphlet will help me improve.

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NEW TITLES

Prepared by Roy John

†Available for review * Assigned

ZOOLOGY

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* **Songbird Journeys: Four Seasons in the Lives of Migratory Birds.** By Mary Chu. 2006. Walker & Company, 104 Fifth Avenue, New York, New York 10011 USA. 312 pages. U.S. $23.00 Cloth.

Snake Venoms and Evenomations. By J-P. Chippaux. 2006 English Edition. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. 300 pages. U.S. $58.50.

† **Tracks.** By D. Jackson. 2006. University Press of Mississippi, 3825 Ridgewood Road, Jackson, Mississippi 39211 USA. $36.25 279pages. Cloth.

The Alligator Snapping Turtle. By P. Pritchard. 2006 reprint. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902 USA. 152 pages. U.S. $42.

* **Turtles of the World.** By F Bonin, B Devaux and A Dupre. 2006. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363, USA. 416 pages. U.S. $50 Cloth.

Whales, Dolphins and Seals – A Field Guide to the Marine Mammals of the World. By Hadoram Shirihai and Brett Jarrett. 2006. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN, U.K. 384 pages, £12.99 Cloth.

BOTANY

Botanical Riches – Stories of Botanical Exploration. By R. Aitken. 2007. Ashgate Publishing, Box 2225, Williston Vermont 05495. 256 pages. U.S. $ 50 Cloth.

Wildflowers of the Rocky Mountains. By G. Scotter. 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 256 pages. $29.95 Paper.

* **Wild Orchids of the Canadian Maritimes and Northern Great Lakes Region.** By Paul Martin Brown. 2006. University Press of Florida, 15 Northwest 15th Street, Gainesville, Florida 32611-2079 USA. 366 pages. U.S. $ 29.95

* **Wild Orchids of the Pacific Northwest and Canadian Rockies.** By Paul Martin Brown. 2006. University Press of Florida, 15 Northwest 15th Street, Gainesville, Florida 32611-2079 USA. 304 pages. U.S. $ 29.95

ENVIRONMENT

Algonquin Souvenir. By M. Runtz. 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 96 pages. $19.95 Cloth.

An Artist's and Photographer's Guide to Wild Ontario. By R. Stimson and C. Thompson. 2006. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 224 pages. $29.95 Paper.

The Enchantment of Birds. By R. Cannings. 2007. Greystone Books, Suite 201, Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 168 pages. $29.95 Cloth.

The International Politics of Bird Conservation. By R. Boardman. 2006. Edward Elgar Publishing, 9 Dewey Court, Northampton, Massachusetts 01060 USA. 288 pages. U.S. $110 Cloth.

* **The Atlas of Climate Change.** By Kirstin Dow and Thomas E. Downing. 2006. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN, U.K. £12.99, Paper.

Principles of Population Genetics – 4th edition. By D. Hart and A. Clark. Sinauer Associates, Box 407, Sunderland, Massachusetts 01375 USA. 565 pages. U.S. $93.95.

An Inconvenient Truth. By Al Gore. 2006. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN, U.K. £14.99.

The Rough Guide to Climate Change. By Robert Henson. 2006. NHBS Environment Bookstore, 2-3 Wills Road, Totnes, Devon TQ9 5XN. U.K. £9.99.

* **The Reluctant Mr. Darwin: An Intimate Portrait of Charles Darwin and the Making of His Theory of Evolution.** By David Quammen. 2006. Atlas Books, 10 East 53rd Street, 36th Floor, New York, New York 10022, USA. 304 pages. U.S. $22.95.

† **Marshes.** By W. Burt. 2007. Yale University Press, P.O. Box 209040, New Haven, Connecticut 06520-9040 USA. 192 pages. U.S. $35 Paper.

Nature's Engraver – A life of Thomas Bewick. 2007. Farrar Straus Giroux, North Point Press, 19 Union Square West, New York, New York 10003. 480 pages. $27.50 Cloth.

Wild Nova Scotia. By L.Wagg. 2006. Nimbus Publishing, Box 9166, Halifax, Nova Scotia B3K 5M8 Canada. 96 pages $29.95.

People, Fish and Whales – The Vancouver Aquarium Story. By Dr. Murray Newman. 2006. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 120 pages. $19.95 Paper.

* **Pilgrimage to Vallombrosa – From Vermont to Italy in the Footsteps of George Perkins Marsh.** By John Elder. 2006. University of Virginia Press, 210 Sprigg Lane, Charlottesville, Virginia 22903 USA. U.S. $33.99 Cloth.

Sarcophaginae et Paramacronychiinae du Proche Orient (Insecta, Diptera, Sarcophagidae). By A. Lehrer. 2006. Pensoft Publishers, Sofia-Moscow. [In French.], 264 pages. EURO 64.00 Cloth.

Tales from the Thébaïde- Reflections of a Turtleman. By P. Pritchard. 2006. Krieger Publishing Company, P.O. Box 9542, Melbourne, Florida 32902-9542 USA. 340 pages. U.S. $44.50.

Wild Borneo. By N. Garbutt and J. Prudente. 2006. The MIT Press, Five Cambridge Center, 4th Floor, Cambridge, Massachusetts 02142-1493 USA. 176 pages. $34.95 U.S.

The End of the Wild. By S. Meyer. 2006. The MIT Press, Five Cambridge Center, 4th Floor, Cambridge, Massachusetts 02142-1493 USA. 96 pages. U.S. $14.95.

† **Wildfire in the Wilderness.** By C. Czajkowski. 2006. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 224 pages. $19.95.

Endangered Wildlife on the Brink of Extinction. By G. McGavin. 2006. Firefly Books Ltd., 66 Lark Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 142 pages. $35. Cloth.

YOUNG NATURALISTS

Tale of a Great White Fish – A sturgeon story. 2007. Greystone Books, Suite 201 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 48 pages. $10.95 Cloth.

SPECIAL NOTE

Sale of the Herpetological Library of Adrian Crane (800 items including antiques). PDF catalogue from Breck@herplit.com

News and Comment

Marine Turtle Newsletter (112)

April 2006. 28 pages: ARTICLES: Nesting of Green Turtles in Saint Leu, Reunion Island (S. Ciccione and J. Bourjea) — Sea Turtles and Fishery Interactions in Brazil: Identifying and mitigating potential conflicts (M. A. Marcovaldi, G. Sales, J. C. A. Thome, A. C. C. Dias da Silva, B. M. G. Gallo, E. H. S. M. Lima, E. P. Lima, C. Bellini) — First Report of Leatherback Turtle Entanglement in Trap Lines in the Uraguayan Continental Shelf (M. Laporta, P. Miller, S. Horta, and G. Riestra) — Loggerhead Turtle Nesting Activity in Kuriat Islands (Tunisia): Assessment of Nine Years Monitoring (I, Jribi, M. N. Bradai and A. Bouain) — Hawksbill Turtles on the Pacific Coast of Costa Rica (A. Gaos, R. Arauz and I. Yanez) — NOTES: Oceanic Movement of Benthic Foraging Juvenile Hawksbill Turtle from The Cocos (Keeling) Islands (S. D. Whiting and A. U. Koch) — Use of Marine Turtles in Zootherapy in Northeast Brazil (R. Romeu da N. Alves) — MEETING REPORTS — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

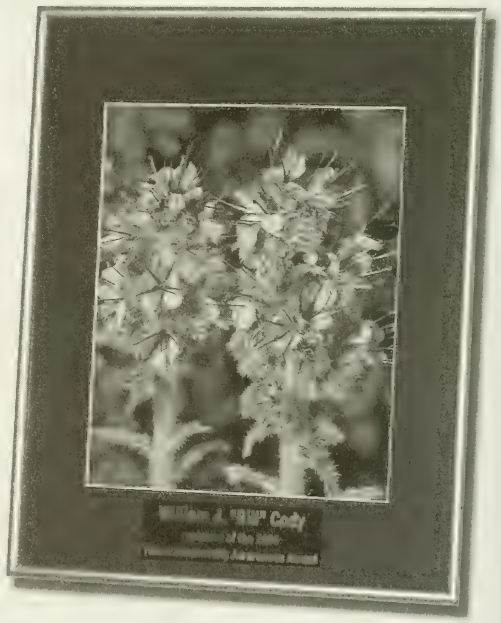
The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

Herpetological Survey 2006 Atlas of Amphibians and Reptiles of Quebec

Instructions for participants in the 19th herpetological survey for the Quebec Atlas of amphibians and reptiles, coordinated by the St. Lawrence Natural History Society in collaboration with the Ministère des Ressouces naturelles de la Faune du Québec. This provincial inventory is done every year with the important cooperation of volunteers. Observation cards to fill out and details of information needed can be obtained from David Rodrique, Director, Research and Conservation, Program Coordinator, or Mathieu Oulette, Research and conservation, St. Lawrence Valley Natural History Society, Ecomuseum, 21 125 chemin Saint-Marie, Saint-Anne-de-Bellevue, Quebec H9X 3Y7; phone 514-457-9449, extension 105; fax 514-457-0769; e-mail: info@herpetofaune.org. Current information on The Atlas of Amphibians and Reptiles of Quebec is now available online at the St. Lawrence Natural History Society website: www.herpetofaune.org.

Bill Cody Receives Yukon Biodiversity Awareness Award

From 1946 to 1987 Bill (W.J.) Cody was employed with Agriculture and Agri-Food Canada as plant taxonomist and curator of Canada's largest collection of plants. From 1988 to 2006 he has continued to come in to work every day as an Honourary Research Associate and he has made a series of remarkable contributions to our knowledge of the plants of northwestern North America. His 643 page textbook on the Flora of the Yukon was published in 1996. It included current information on status, distribution, ecology, classification and identification. In 1997 this outstanding work was recognized with the prestigious Lawson Medal awarded by the Canadian Botanical Association. An updated second edition of the book was published by the National Research Council in 2000. Since his retirement Bill has published 14 articles on the flora of the Yukon in scientific journals. He has provided an enormous amount of information on plants to the agricultural sector, natural resources staff, wildlife biologists, native people and landscape planners. Always willing to help, he has identified a thousand plants from the Yukon every year. It is therefore not a surprise that Bill has been recognized for his outstanding service with the Yukon Biodiversity Awareness Award. The award honours those who have made major contributions to educating people about biodiversity and its importance.



Bill started as an assistant with the Canada Department of Agriculture in Ottawa. Twenty-one years later in 1967 he was made a Research Scientist. This classification was generally reserved for people who had a Ph.D., but Bill's outstanding accomplishments at that time were judged by his colleagues and the science arm of the federal civil service to warrant treatment at the Ph.D. level. The awards that Bill has received since then are numerous, but one in particuar draws attention his broad contribution. In November 2002 he received a Queen's Golden Jubilee Commerorative Medal. These medals were awarded to a limited number of people who have made a significant contribution to Canada, in this case "especially for his work on *The Canadian Field-Naturalist*, Canada's foremost scientific journal for field biology." Bill has served as the business manager, article and book review contributor, and manuscript reviewer for this journal for 60 years, and his influence on its development, support, improvement and content is beyond question.

Bill also served as curator of the largest dried plant collection in Canada from 1959 to 1988 and was largely responsible for its development. This collection of now over 1 million specimens has become a major tool of Agriculture and Agri-food Canada for plant identification.This collection provides a wealth of information that is needed to implement Agriculture and Agri-food Canada's Biodiversity Strategy and to respond to the International Convention on Biodiversity. It is particularly valued as a tool for improved plant classification studies used by researchers in other institutions both in Canada and worldwide. It is also important in protecting Canada's borders and enforcing federal regulations. Many thousands of specimens that Bill collected in the northern wilderness under extreme and dangerous conditions are part of this collection and serve as vouchers for his numerous publications and books.

Bill was born in Hamilton on 2 December 1922. His father was a doctor and his mother a nurse at Hamilton General. He grew up in Hamilton and received his B.A. from McMaster University in 1946.

The Yukon Biodiversity Awareness Award plaque that Bill received included a photo of one of Yukon's rarest plants, McBride's Phacelia (*Phacelia mollis*) which is a Beringian endemic (confined to the unglaciated area of Alaska and Yukon).

Text slightly modified from that provided courtesy of Paul Catling, Canada Agriculture and Agri-food, Ottawa. Photograph of the award plaque courtesy Stephen Daryshire, Canada Agricuture and Agri-food, Ottawa.

Errata *The Canadian Field-Naturalist* 120(1)

Book Review. Lapland a Natural History, pages 123-124: replace "Redcliff" and Redcliffe" with Ratcliffe, throughout.

Articles.

Diversity and range of amphibians and reptiles of the Yukon Territory. Brian G. Slough and R. Lee Menell in Literature Cited page 91 "Matsurla" should read Matsuda.

Recent Declines of House Sparrows, *Passer domesticus*, in Canada's Maritime Provinces. Anthony J. Erskine.
Page 48 insert following Dunn et al.
Erskine, A. J. 1980. A House Sparrow die-off. Nova Scotia Bird Society Newsletter 22: 183-184.
For reference following Erskine 1992b insert **Erskine** before initials.

Editor's Report for Volume 119 (2005)

Mailing dates for issues in volume 119: (1) 6 June 2006, (2) 13 June 2006, (3) 30 November 2006, (4) 17 April 2007. A summary of membership and subscriber totals 2004 is given in Table 1. The number of articles and notes in volume 119 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4.

Council continued to authorize 40% of membership dues for publication of the journal and all of subscriptions (both individual and institutional). Council also has allocated 80% of the annual interest from the Manning Fund and other capital funds to *The Canadian Field-Naturalist*. Use of the Manning fund portion was broadened on an issue-by-issue basis to offset the publication costs where author and institutional contributions were insufficient to cover page charges.

The journal was printed at Gilmore Printers, Ottawa, and thanks are due business representative Tom Smith, customer representative Chuck Graham for overseeing production, and Wendy Cotie for typesetting and corrections. Leslie Cody prepared the Index for volume 119; Elizabeth Morton proofed the galleys. Long-time (60 years) Business Manager for the journal, Bill Cody, gradually relinquished much of his active role during the year and some of his duties were shouldered by treasurer Frank Pope and assistant treasurer Jim Ward. Roy John processed books sent by publishers, assigned reviewers, edited book reviews and prepared the New Titles listing. Sandra Garland the Ottawa Field-Naturalists' Club webmaster, posted contents and abstracts from each issue as it appeared, and sent pdfs of articles and notes ordered by authors.

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 75 in 2005, equalling the total for 2004. The following reviewed papers submitted in 2005 (with number of manuscripts reviewed in parentheses if more than one):

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 119 (2005) by major field of study.

Subject	Articles	Notes	Total
Mammals	19	17	36
Birds	14	5	19
Amphibians + reptiles	2	1	3
Fish	6	1	7
Invertebrates	7	2	9
Plants	13	1	14
Other	1*	0	1
Totals	62	27	89

Associate Editors:

R. Anderson, Canadian Museum of Nature, Ottawa, Ontario (2); C. D. Bird, Erskine, Alberta (9); R. R. Campbell, St. Albert, Ontario (3); P. M. Catling, Agriculture and Agri-food Canada, Ottawa (7); B. W. Coad, Canadian Museum of Nature, Ottawa (8); A. J. Erskine, Sackville, New Brunswick (12); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (9); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (9); W. O. Pruitt, Jr., University of Manitoba, Winnipeg (16).

Additional Reviewers: W. B. Ballard, Texas Tech University, Lubbock, Texas (3); L. Bernatchez, Laval University, Quebec, Quebec; J. R. Bider, Baie o'Urfe, Quebec; G. Blouin-Demers, University of Ottawa, Ontario; D. Boyd, Helena, Montana; M. Brigham, University of Regina, Saskatchewan; L. Carbyn, Canadian Wildlife Service, Edmonton, Alberta (3); J. Cayouette, Agriculture and Agri-Food Canada, Ottawa; J. Cebek, Trent University, Peterborough, Ontario; T. Chubbs, Happy Valley – Goose Bay, Labrador, Newfoundland & Labrador (3); H. D. Cluff, Resources, Wildlife & Economic Development, Yellowknife, Northwest Territories (2); M. Crete, Ministre de l'Environment, Quebec, Quebec; A. W. Diamond University of New Brunswick, Fredericton, New Brunswick (2); L. C. Dickamer, Northern Arizona University, Flagstaff Arizona; P. Dobson, School of Veterinary Medicine, Philadelphia, Pennsylvania; J. Eger, Royal Ontario Museum, Tor

TABLE 1. The 2005 circulation of The Canadian Field-Naturalist (2004 in parenthesis). Compiled by Robin Murphy, bmrgroup Ottawa.

	Canada		USA		Other		Totals	
Memberships								
Family & individual	624	(717)	26	(26)	6	(6)	656	(749)
Subscriptions								
Individuals	130	(165)	63	(63)	4	(5)	197	(233)
Institutions	156	(164)	229	(246)	34	(30)	419	(440)
TOTALS	910	(1046)	318	(335)	44	(41)	1272	(1422)

Note: 22 countries are included under "Other" (outside Canada and United States): Austria, Belgium, Brazil, Denmark (2), United Kingdom (9: including 1 to Scotland), Finland (2), France (3: including 1 to St. Pierre & Miquelon), Germany (2), Iceland Ireland, Japan, Mexico, Netherlands (3), New Zealand, Norway (4), Poland, Russia, South Africa, Spain (3), Sweden (2 Switzerland (2), Trinidad and Tobago.

TABLE 3. Number of reviews and new titles published in Book Review section of *The Canadian Field-Naturalist* Volume 119 by topic.

	Reviews	New Titles
Zoology	33	104
Botany	5	19
Environment	17	10
Miscellaneous	6	20
Young Naturalists	0	2
Totals	61	155

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist* Volume 119 (2005) by issue.

	(1)	(2)	(3)	(4)	Total
Articles	128	132	118	95	473
Notes	12	8	21	16	57
Book Reviews*	15	20	11	19	65
CFN/OFNC Reports**	0	2	8	4	14
News and Comment	2	2	1	1	6
Index	0	0	0	32	32
Advice to Contributors	1	0	1	1	3
Totals	158	164	160	168	650

* Total pages for book review section include both reviews and new titles listings.

** Includes CFN Editor's report in (2), OFNC Annual Business Meeting (3) and OFNC Awards (4).

onto, Ontario; W. Foissner, Institut fur Zoologie, Salzburg, Austria; B. Freedman, Dalhousie University, Halifax, Nova Scotia; W. A. Fuller, Athabasca, Alberta; D. M. Green, Redpath Museum, McGill University, Montreal, Quebec (4); P. T. Gregory, University of Victoria, British Columbia (3); E. Haber, National Botanical Services, Ottawa, Ontario; F. H. Harrington, Mt. St. Vincent University, Halifax, Nova Scotia; V. L. Harms, University of Saskatchewan, Saskatoon; T. Haxton, Ministry of Natural Resources, Kemptville, Ontario (2); S. Herrero, University of Calgary, Alberta (2); G. Holroyd, Canadian Wildlife Service, Edmonton, Alberta; E. Holm, Royal Ontario Museum, Toronto; S. Hooker, University of St. Andrews, Fife, United Kingdom; C. S. Houston, Saskatoon, Saskatchewan; R. James, Sutherland, Ontario (2); M. Johnson, Game & Fish Department, Bismarck, North Dakota; T. S. Jung, Environment, Fish and Wildlife Branch, Whitehorse, Yukon (2); R. W. Knapton, Edmonton, Alberta; K. Larsen, University College of the Cariboo, Kamloops, British Columbia; J. Lien, Memorial University of Newfoundland, St. John's; R. MacCulloch, Royal Ontario Museum, Toronto, Ontario; F. F. Mallory, Laurentian University, Sudbury, Ontario (2); J. Maunder, Pond Cove, Newfoundland (3); L. D. Mech, U.S. Geological Survey, The Raptor Center, University of Minnesota, St. Paul (3); R. Meisterfeld, Institute for Biology II (Zoology), Department of General Biology, Aachen; D. Naughton, Canadian Museum of Nature, Ottawa; J. S. Nelson, University of Alberta, Edmonton; J-P. Ouellet, Universite du Quebec a Rimouski; P. Paquet, Meacham, Saskatchewan (3); D. Paulson, Seattle, Washington; G. Parker, Canadian Wildlife Service, Sackville, New Brunswick; S. Petrie, Bird Studies Canada, Port Rowan, Ontario; G. Proulx, Alpha Research & Management Ltd., Sherwood Park, Alberta (2); Raine, Golder Associates Ltd., Calgary, Alberta; R. Reeves, Okapi Wildlife Associates, Hudson, Quebec; J. D. Rising, University of Toronto, Ontario; L. Rogers, Ely, Minnesota; R. Rosatte, Ministry of Natural Resources, Trent University, Peterborough, Ontario; A. Russell, University of Calgary, Alberta; S. Sampson, Utah Museum of Natural History, Sault Lake City; Fred Scott, Acadia University, Wolfville, Nova Scotia; F. W. Schueler, Bishops Mills Natural History Center, Oxford Mills, Ontario (6); F. E. Schwab, College of the North Atlantic, Labrador City, Newfoundland and Labrador; D. Smith, Southern Connecticut State College, New Haven; K. W. Stewart, University of Manitoba, Winnipeg, Manitoba; J. Theberge, Oliver, British Columbia (3); I. Thompson, Canadian Forest Service, Sault Ste. Marie, Ontario (2); P. M. Youngman, Ottawa, Ontario.

I am also indebted again to the President of the Ottawa Field-Naturalists' Club Gary McNulty and the Club Council for continuing support of the journal; Chairman Ron Bedford and the Publications Committee of the OFNC for editorial encouragement and support, the finance committee for input and encouragement to speed things up, the Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Aylmer, Quebec, and to Joyce for continuing support.

FRANCIS R. COOK
Editor

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit by post **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** Manuscripts may also be submitted (one copy) by e-mail. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be printed on standard-size paper, **doublespaced throughout,** generous margins to allow for copy marking, and **each page numbered.** For Articles and Notes provide a bibliographic (citation) strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "British" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the joumal.

Special Charges — Please take note

Authors **must share in the cost of publication** by paying $90 for each page, plus $20 for each illustration (any size up to a full page), and up to $90 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Editor. If grant or institutional funds are not available, club members and subscribers may apply for a waiver of charges for the first five pages.

Limited joumal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

Reprints

An order form for the purchase of repents will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor
RR 3 North Augusta, Ontario K0G IR0 Canada

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COVER: A Screech-Owl peers down from a perch at the McGill Bird Observatory in the Stoneycraft Wildlife Area, Ste-Anne-de-Bellevue, Quebec. Photographed 11 October 2004 by Marcel Gahbauer; e-mail: marcel@migrationresearch.org. See article by Richards, Mineau, Bird, Wery, Larivée and Duffe, pages 289–297.

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An Ethogram Developed on Captive Eastern Coyotes *Canis latrans*

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Way, Jonathan G., Dean-Lorenz M. Szumylo, and Eric G. Strauss. 2006. An ethogram developed on captive eastern Coyotes *Canis latrans*. Canadian Field-Naturalist 120(3): 263-288.

We studied capture Eastern Coyotes (*Canis latrans*) from 27-585 days of age and compiled an ethogram on them. A total of 72247 15-sec samples were taken, amounting to 301 h of field time varying between 59.4–61.3 h per Coyote. A total of 540 behavioral patterns was observed amongst the 16 behaviour categories ranging from 9 (miscellaneous) to 72 (explore investigate) action patterns per parent category. The 16 parent categories that we believed best described and appropriately sorted the behavioural actions were resting, sitting, sitting1, sitting2, standing, traveling, explore investigating, hunting, feeding, infantile, greeting, self play, play initiating, playing, agonistic, and miscellaneous. Exploring accounted for >31% of all of the behaviours observed with resting and sitting (combined), standing, traveling, and play as categories decreasing in order of most to least frequent. Despite some omissions in our ethogram and drift associated with its ongoing development, we believe that the large amount of data collected made it rigorous enough to be a useful guide for the species. We argue that although future research will no doubt add to and/or modify components of it, its ease of use in the field (in captivity or in the wild) and it being the first complete ethogram described for the species, make it a useful tool for future researchers.

Key Words: canid, *Canis latrans*, eastern Coyote, ethogram, behavioural study.

The concept of an ethogram, also called action system (Makkink 1936), behavioural inventory (Bekoff 1972a, 1978), or behaviour pattern (Scott and Fuller 1965), is a durable tool for analyzing vertebrate behaviour and dates back to Jennings (1906), Makkink (1936), Tinbergen (1959), and Lorenz (1971). Although there have been direct observation behavioural studies of Coyotes (*Canis latrans*) in captivity (Snow 1967; Silver and Silver 1969; Bekoff 1972a, 1978; Parks 1979; Ryon 1986) and in the wild (Camenzind 1978; Bekoff and Wells 1981; Gese et al. 1996), there has yet to be a standardized and complete ethogram published for the species. Except for Goodmann and Klinghammer's (1990) non-peer reviewed but detailed manual which presents a Wolf (*Canis lupus*) ethogram and Scott and Fuller's (1965) ethogram on Domestic Dogs (*Canis familiaris*) (which they compared with literature on Wolves, Coyotes and Red Foxes [*Vulpes vulpes*]), we could not find any other study that described a full behavioural repertoire of any other of the approximately 35 canid species (Ewer 1973; Wozencraft 1989). Most studies examining behavioural data have focused on specific time periods (e.g., young pups/behavioural development – Bekoff 1972a, 1978, 1989), specific actions (e.g., social interactions – Fox 1970; Bekoff 1974; Zimen 1982), lumping behaviours into general categories (Silver and Silver 1969; Parks 1979; Gese et al. 1996), or describing many behavioural patterns but providing no summary or chart showing a complete ethogram (Mech 1970; Lehner 1978). Schleidt et al. (1984) termed these "partial ethograms" and stated the importance of publishing complete ethograms on as many species as possible. In addition, Macdonald et al. (2000) underscored the significance of developing ethograms on different species by stating that without one, meaning is not fixed. As such, ethograms are vital reference material for assessing a study's conclusions (Macdonald et al. 2000).

The objective of this paper is to describe, in detail, the full range of behavioural acts that we have observed in a captive group of five Eastern Coyotes. This ethogram is intended to be: (1) reader-friendly in format and applied and used in future direct observation behavioural studies of wild and captive Coyotes; and (2) compared with ethograms of closely related species (e.g., Wolves, Jackals [*Canis* sp.] and foxes) and taxa (e.g., ursids, procyonids, and mustelids: Ewer 1973).

Methods

On 12 April 2002, five (2 M; 3 F) of an original litter of nine (3 M; 6 F) estimated 25 day old (Parks 1979), wild-born sibling Coyote pups were removed from under a shed in a residential area in Falmouth (Cape Cod), Massachusetts, and were reared at JGW's house (note: the other four pups [1M; 3F] were placed back underneath the shed for the wild parents to raise). The five Coyotes taken into captivity were contained within a 53 m^2 area both inside and outside of JGW's house until 13 May 2002, when the Coyotes were transferred to a 16 m^2 quarantine facility for one month at the Franklin Park Zoo, Boston, Massachusetts. On 13 June 2002 the five Coyotes were moved to their permanent 403 m^2 public viewable exhibit at the Stone Zoo located in Stoneham, Massachusetts, and remained there for the duration of this study until late October 2003 – pup age 585 days). We chose the endpoint of our study as the last day of data collection prior to the Coyotes being permanently separated due to intrapack aggression (Late and Trans [See Table 1] were removed). The area of their exhibit was described by Frank (1987) as a suitable size for a long-term study of canid behaviour. Although the Coyotes were hand-raised, we made no attempt to interfere with or discipline their activities and therefore gave the Coyotes free access, at all times, to their exhibit/living facilities. The Coyotes were provided with puppy milk (Esbilac, PetAg, Inc., Hampshire, Illinois) via bottle or bowl up until 15 May and were given access to water and dry dog chow (commercially available dog foods until March 2003 then Mazuri exotic canine chow/diet [PMI Nutrition International, LLC., Brentwood, Missouri] thereafter) at all times. They were group fed (i.e., all five at once) 0.75 – 1.6 kg (varying with their age) of Nebraska Brand chopped frozen canine meat (Central Nebraska Packing Co., North Platte, Nebraska) mixed with dog chow on a daily basis and were given frozen or thawed laboratory rats, guinea pigs and mice (donated from a rodent breeding facility), and/or bones 2-4 times per week. Within their exhibit, the Coyotes commonly hunted (at least 1 prey item 2-3 times daily) and captured (about 1-2 prey items per week) Starlings (*Sturnus vulgaris*), House Sparrows (*Passer domesticus*), Chipmunks (*Tamias striatus*), Brown/Norway Rats (*Rattus norvegicus*), Meadow Voles (*Microtus pennsylvanicus*), and Gray Squirrels (*Sciurus carolinensis*), but did not appear to eat much or any of these prey items. Care and use of animal subjects was approved by Zoo New England's Institutional Animal Use and Care Committee (letter dated 23 January 2002 to JGW), by Boston College's Institutional Animal Care and Use Committee Protocol Number 01-03, and by the Massachusetts Division of Fisheries and Wildlife Permit #052. 02LP.

We developed an ethogram that noted basic behavioural patterns (Scott and Fuller 1965; Bekoff 1972a, 1972b, 1978; Parks 1979). To avoid influencing Coyote behaviour with different observers only JGW interacted with and conducted activity budgets on them. Using this technique, we acknowledge that we did not have interobserver reliability as described by Bekoff (1974) but the large amount of data collected attempted to offset intraobserver reliability. We used focal individual animal sampling (i.e., one Coyote per 30 min bout of data collection), took instantaneous point or scan samples (Martin and Bateson 1986; Macdonald et al. 2000) every 15 sec for 30 min on the target Coyote, recorded the date, time, and weather before each observation bout took place, and noted important contextual information in between each 15 sec sampling period. By using frequent (i.e., every 15 sec) instantaneous samples, we tried to obtain an accurate approximation from continuous recording (Martin and Bateson 1986). Thus, 120 samples per 30 min behavioural bout on a Coyote were ideally recovered. However, there were two reasons why we occasionally did not obtain 120 samples per bout: (1) a Coyote was momentarily out of sight during a particular 15 sec sampling period (usually this happened at most, once per 30 min bout); and (2) we had to stop a sampling bout earlier (e.g., rain, darkness, or some kind of disturbance that forced JGW to abandon an activity budget). We randomly chose which Coyote to conduct observations on before entering the field but attempted to evenly sample all Coyotes (i.e., each Coyote was scored every fifth time) during the study. We typically recorded behavioural data about 5 days/week and took between 1 and 4 (usually 1-2) 30 min behavioural bouts/day during daylight hours. Behaviours were also recorded on digital still and videocameras and 35-mm film cameras weekly for the duration of the juvenile period of the pups (Parks 1979) then *ad lib* after pups reached adulthood (one yr of age – Bekoff and Jamieson 1975). We conducted most of the behavioural bouts during early to mid-morning (ca. 07:00-11:00 h) or between late-afternoon to early-evening hours (ca. 16:00-19:30 h); these were the times with the fewest number of people around the zoo (the zoo opened at 10:00 and closed at 16:30-1800 h depending on the time of year). Because the Coyotes were habituated to and did not react negatively to JGWs presence, he followed them around the exhibit similar to the description of Goodall's (1986) "follows" of wild Chimpanzees (*Pan troglodytes*) in Gombe, Tanzania. JGW made an effort not to influence the movements and/or behaviour of Coyotes by minimizing his movement in the exhibit. This was especially important because the Coyotes would follow him around the exhibit when he interacted with them but would generally ignore him when he was standing erect and writing on a clipboard (J. Way, unpublished data). "Following" was a necessary technique to use on the Coyotes because there was not a single observation spot outside the exhibit where the Coyotes could reliably be seen all of the time (i.e., many times trees and shrubs concealed the Coyote under observa-

tion). Besides the senior author's presence, other human contact was kept to a minimum before and after each sampling period to avoid humans affecting Coyote behaviour. Context was a critical variable with respect to the Coyotes' response to human behaviour. For example, they generally ignored people (unless very loud) on the public path but would intently watch and/or bark at staff members that were behind (i.e., the opposite side of the public path that was off-limits to non-employees) or approaching their exhibit. Accordingly, zookeepers did not enter the exhibit to feed the Coyotes when JGW interacted with them. Despite these precautions there were no doubt many instances where Coyotes changed their activity in response to a person's (public or staff) presence – sometimes even when a person simply walked by their exhibit area. Similar instances of Coyotes shifting their behaviour because of the presence of people have been documented in areas where wild Coyotes inhabit urbanized areas (Way 2001). We attempted to mitigate these factors by increasing the total size of the pool of sample bouts.

We entered all of the data into an excel spreadsheet. First, we entered the raw data into the spreadsheet. Then we alphabetized that data in order to group similar behaviours for each budget. Next we summed the frequency of each distinct behaviour observed. Finally we entered those summed values into a separate file (for each Coyote) that had our developing ethogram. Due to the large amount of data and behaviour sequences in our ethogram (Table 1), properly entering and compiling data were critical parts of this ethogram's creation. Behavioural actions or patterns (denoted as subcategories in Table 1), as defined by Scott and Fuller (1965), were grouped into "parent" categories, or behavioural complexes as described by Schleidt et al. (1984), or behavioural systems, as noted by Scott and Fuller (1965), based on motivational context and activity observed (Parks 1979).

In our ethogram, we organized the categories and the behavioural actions within each of the complexes generally on a scale from less to more active or intense an activity, then from solitary to group-oriented activities. Notable exceptions were feeding, which was grouped next to hunting for obvious reasons, and self play, which was grouped close to social play but was of a solitary endeavor. The 16 parent categories that we believed best described and appropriately sorted the behavioural actions were resting, sitting, sitting1, sitting2, standing, traveling, explore/investigating, hunting, feeding, infantile, greeting, self play, play initiating, playing, agonistic, and miscellaneous. There were instances (especially early in our study when we were working on differentiating different behavioural actions) where a Coyote was engaged in an activity but we could not describe, other than in a general category, what the Coyote was doing. When this occurred (e.g., when a Coyote was behind trees and was only partially observed) we simply classified the behaviour in its parent category, so that we could at least provide a coarse description of a Coyote's behaviour at a given 15 sec interval (Table 1).

We calculated the percentage that each behaviour pattern was observed and added all within a parent category to examine the relative frequency that each behavioural complex/system occurred (Table 1). In addition, we used the ages (in days) of the Coyotes to denote the first time that each behaviour was observed, with day 27 (14 April 2002) being the beginning point – i.e., the date we first did an ethogram on a Coyote. We want to stress here that although we report both the percentage of each behaviour observed and the age that each behaviour was first recorded for comparison purposes (Table 1), the purpose of this manuscript is to describe the ethogram that we developed. We will more thoroughly analyze these data in future manuscripts.

Results and Discussion

The ethogram that we developed on the Eastern Coyote is presented as Table 1. A total of 72247 15-sec samples were taken amounting to 301 h of field time, varying between 59.4-61.3 h per Coyote. A total of 540 behavioural patterns were observed amongst the 16 behaviour categories ranging from 9 (Miscellaneous) to 72 (Explore and Investigate) acts per parent category (Table 1; Figures 1-25).

Resting (RE) occurred when a Coyote was lying down with its head on the ground. Sitting (SIT) was classified as sitting down either on rear or all four legs; this category was subsequently divided into sit1 (SIT1) and 2 (SIT2). SIT1 was noted when a Coyote was sitting down on all four legs; in other words, it was almost lying down but it had its head up. SIT2 was when a Coyote sat on its rear legs but its front legs were up in standing-like position. It was difficult to always reliably determine what the motivation was for a Coyote in the aforementioned positions. For example, a Coyote frequently sat in SIT1 position to sniff the ground. Because the animal was in a resting-like position we believed that it was important to separate these activities from explore/investigate activities where the animal was active (i.e., at least in a standing position). Similarly, it was sometimes difficult to understand the motivational context when an animal was just standing (ST) and performing routine activities. Thus, we developed a category for just standing activities.

Any of these categories could always be lumped together or put into different or new categories if the need arose – but the opposite cannot occur if the behaviours are not split into discrete actions at the outset (Bekoff 1972b). For example, SIT1 Alt and SIT1 Alt Pt were very similar except for the panting involved. Although we could have easily combined these categories we thought that keeping them separated would allow us to potentially analyze this difference in the future (e.g., the level of panting on hot versus cold days).

Resting and sitting behaviours were observed quite frequently and accounted for >23% of all of the ethogram despite the Coyotes generally being much more

TABLE 1. Ethogram on eastern Coyotes: "Age" refers to the age of the Coyotes (in days) when a behavior was first observed (data collection began on day 27 for Lupe and day 33 for others); "%" refers to the percentage of each behavioral pattern observed relative to the total number of samples (spot fixes) taken; a zero signifies that the behavior was either never recorded for a Coyote(s) or was <0.0049% (i.e., not rounded up to 0.01%); and letters in parentheses refer to abbreviations from the previous word(s) or phrase(s).

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
Resting (RE)	Coyote lying down with its head on the ground	27	1.49	39	34	34	27	33	1.18	2.08	2.11	1.36	0.74
Sniff (sn)	Sniffing ground or air while lying	54	0.03	54	0	67	147	55	0.12	0.00	0.01	0.01	0.01
Alert (alt)	Eyes open and alert (focused) while lying	39	0.88	39	43	48	58	48	1.26	1.19	0.48	0.92	0.54
Pant (pt)	Panting with no comment on eye activity	99	0.01	0	0	108	99	0	0.00	0.00	0.05	0.01	0.00
Alt pt	Alert and panting while lying	99	0.02	149	464	0	99	0	0.01	0.01	0.00	0.07	0.00
Yawn	Yawning while lying	121	0.00	0	121	0	0	0	0.00	0.01	0.00	0.00	0.00
Lick self	Licking itself, usually paws while lying	40	0.06	40	50	57	58	43	0.13	0.05	0.05	0.03	0.05
Stretch	Lying and stretch body	75	0.04	122	100	147	75	85	0.04	0.03	0.03	0.07	0.04
Rub head	Rubbing head against object (e.g., tree) or the ground while lying down	94	0.02	148	0	394	97	94	0.01	0.00	0.01	0.03	0.04
Scratch	Lying down and scratching part of body	38	0.04	38	47	53	42	39	0.08	0.02	0.01	0.06	0.03
Eyes (I) open	Eyes open but not focused on anything	49	0.79	57	58	60	58	49	0.78	0.76	0.96	0.65	0.78
I open & stretch	Stretching while staring and lying down	150	0.00	0	0	150	0	0	0.00	0.00	0.01	0.00	0.00
I open pt	Panting while eyes are open	108	0.03	0	0	108	147	0	0.00	0.00	0.10	0.05	0.00
Move head I open	Moving head quickly while lying down; eyes open in the process	542	0.00	0	542	0	0	0	0.00	0.01	0.00	0.00	0.00
I closed (cl)	Eyes closed while lying; does not appear to be sleeping	39	0.89	39	58	67	58	73	0.82	0.76	0.94	0.96	0.97
I cl pt	Same as above with panting	108	0.08	122	108	108	147	149	0.01	0.01	0.21	0.13	0.04
I cl licking motion	Making a licking motion while eyes are closed	541	0.00	0	0	541	0	0	0.00	0.00	0.01	0.00	0.00
I cl & scratch	Scratching self while eyes are closed	148	0.00	148	0	0	0	0	0.01	0.00	0.00	0.00	0.00
I cl & stretch	Stretching while eyes are closed	121	0.00	148	121	177	0	0	0.01	0.01	0.01	0.00	0.00
Blink	Blinking eyes while lying	123	0.26	148	161	157	123	143	0.27	0.11	0.20	0.37	0.34
Blink I pt	Blinking eyes while lying down and panting	121	0.01	0	121	477	464	0	0.00	0.01	0.01	0.01	0.00
Doze	Head nodding back and forth and eyes blinking while lying	75	0.33	82	86	98	87	75	1.06	0.19	0.09	0.22	0.09
Doze pt	Same as above while panting	108	0.01	149	108	0	135	0	0.01	0.01	0.00	0.01	0.00
Roll (to side)	Side-to-side maneuvering while lying down	150	0.00	0	0	150	0	0	0.00	0.00	0.01	0.00	0.00
Twitch I	Quick flickering of eyes while lying down and sleeping	35	0.02	106	0	150	0	35	0.07	0.00	0.03	0.00	0.01
Sleep (Sl)	Eyes closed for >15 sec	42	4.41	57	42	49	42	62	4.15	5.36	5.43	5.10	2.00
Sl pt	Sleeping and panting while lying	108	0.14	149	108	394	111	0	0.01	0.56	0.01	0.14	0.00
Whine	Whining while resting; eyes open	43	0.00	0	0	43	0	0	0.00	0.00	0.01	0.00	0.00
RE N = 28	Total percentage for RE		9.58						10.02	11.17	10.79	10.21	5.66
Sitting (SIT)	Sitting down either on rear or all 4 legs; subsequently divided into sit1 and 2	34	0.02	0	0	34	34	0	0.00	0.00	0.04	0.05	0.00
Doze	Head nodding side to side while sitting	177	0.00	0	0	177	0	0	0.00	0.00	0.01	0.00	0.00
Alt	Eyes open and alert while sitting	60	0.23	64	62	60	60	60	0.10	0.13	0.36	0.35	0.22
Pant I open	Panting while eyes are open but not focused on anything	94	0.00	0	0	0	0	94	0.00	0.00	0.00	0.00	0.01
Sn	Sniffing object while sitting	67	0.14	75	73	67	67	68	0.27	0.09	0.08	0.16	0.08

	Sn & alt	Sniffing (usually the air) while alert	85	0.03	85	134	150	111	185	0.09	0.04	0.01	0.01	0.01
	Alt pt	Alert and panting while sitting	73	0.00	73	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Sn pt	Sniffing something while panting	464	0.00	0	0	0	464	0	0.00	0.00	0.00	0.01	0.00
	Whine	Whining while sitting	85	0.00	0	0	85	0	0	0.00	0.00	0.01	0.00	0.00
	Eee	Squeal-like sound done when a more dominant Coyote approached	82	0.00	0	0	0	0	82	0.00	0.00	0.00	0.00	0.01
	Lick self	Licking self while sitting	49	0.02	75	161	0	64	49	0.02	0.01	0.00	0.05	0.01
	Sn & lick	Sniffing and licking self	77	0.00	0	0	0	77	0	0.00	0.00	0.00	0.01	0.00
	Look ar	Looking around while sitting; not focusing on anything specifically	85	0.00	0	0	0	85	0	0.00	0.00	0.00	0.01	0.00
	Move head	Quickly moving head while sitting; e.g., the movement between being alert and licking self	64	0.00	0	0	64	0	0	0.00	0.00	0.01	0.00	0.00
	Rub head	Rubbing head against object or ground in a sitting position	94	0.00	0	0	0	0	94	0.00	0.00	0.00	0.00	0.01
	Scratch & lick	Scratch and lick self while sitting	71	0.00	0	71	71	0	0	0.00	0.01	0.01	0.00	0.00
	Scratch self	Scratch self while sitting	60	0.04	64	80	60	60	75	0.03	0.01	0.08	0.05	0.03
	Stretch	Stretching from a sitting position	78	0.00	93	0	78	0	0	0.01	0.00	0.01	0.00	0.00
	Bite obj	Biting an object while sitting	64	0.08	79	80	64	70	81	0.10	0.05	0.07	0.16	0.04
	Chew obj	Chewing on an object while sitting	60	0.36	75	62	64	62	60	0.09	0.11	0.30	0.82	0.48
	Tug/pull obj	Tugging or pulling on an object while sitting	62	0.01	0	0	72	62	0	0.00	0.00	0.02	0.01	0.00
SIT	N = 21	Total percentage for SIT:		0.95						0.71	0.45	1.01	1.69	0.89
SIT1		Sitting on all 4 legs; almost lying down but head up	65	0.09	65	96	67	93	97	0.05	0.11	0.10	0.17	0.04
	Sleep	Sleeping in sit1 position	177	0.00	0	0	177	324	0	0.00	0.00	0.01	0.01	0.00
	Doze	Head swaying side to side while dozing on and off; exaggerated blinking takes place; often done prior to lying down or sleeping	169	0.40	324	179	171	169	345	0.18	0.25	0.20	0.53	0.83
	Doze pant (pt)	Same as above with panting	394	0.01	0	464	394	0	0	0.00	0.01	0.02	0.00	0.00
	I closed (cl)	Closing eyes; often eyes are closed in the heat but Coyote not asleep	292	0.04	0	547	292	514	373	0.00	0.01	0.08	0.01	0.08
	I cl pt	Same as above while panting	108	0.03	0	0	108	464	476	0.00	0.00	0.08	0.07	0.01
	I cl lick motion	Eyes closed while tongue makes a licking motion	527	0.00	0	547	0	0	527	0.00	0.01	0.00	0.00	0.01
	I blinking	Not quite dozing but opening and closing eyes rapidly	58	0.06	324	337	311	58	445	0.07	0.03	0.03	0.11	0.08
	Blink I pt	Same as above while panting	465	0.01	0	0	0	0	465	0.00	0.00	0.00	0.00	0.04
	I open	Eyes open but not focused on anything; often done before lying down	102	0.06	102	362	311	445	103	0.08	0.01	0.06	0.03	0.11
	I open pt	Same as above while panting	98	0.02	98	464	100	106	465	0.01	0.01	0.04	0.03	0.01
	Yawn	Yawning while sitting	37	0.07	126	134	98	37	185	0.04	0.06	0.07	0.08	0.09
	Yawn pt	Same as above while panting	339	0.00	0	0	339	0	0	0.00	0.00	0.01	0.00	0.00
	Cough	Coughing while sitting	486	0.00	0	0	0	486	0	0.00	0.00	0.00	0.01	0.00
	Sneeze	Sneezing while sitting	526	0.00	0	0	0	526	0	0.00	0.00	0.00	0.01	0.00
	Sniff (sn)	Sniffing the ground	57	1.16	57	80	78	85	62	1.36	0.67	0.72	2.20	0.80
	Sn pt	Same as above while panting	464	0.01	0	0	466	464	465	0.00	0.00	0.01	0.03	0.01
	Sn growl	Sniffing something and simultaneously growling; usually growling at another pup; not Ag because the growl was not directed at a conspecific	174	0.00	0	0	0	174	0	0.00	0.00	0.00	0.01	0.00
	Sn self	Sniffing self	145	0.00	145	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Sn coy	Sniffing another Coyote while in sit1 position	122	0.05	122	0	0	514	0	0.04	0.00	0.00	0.21	0.00
	Alert (alt)	Alert/focused on an object	37	4.95	38	37	40	37	39	4.59	4.10	2.90	7.27	5.83
	Alt pt	Same as above while panting	94	0.78	102	108	100	106	94	0.65	0.31	0.89	1.18	0.85

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent	Subcategory	Description	Age	%	Age					%				
			All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
	Alt yawn	Focused on something while yawning	134	0.00	0	134	339	0	368	0.00	0.01	0.01	0.00	0.01
	Alt & stretch	Focused on something while alert	119	0.01	126	119	177	0	0	0.01	0.01	0.01	0.00	0.00
	Alt & sn	Sniffing something (usually air) while focused on something	135	0.01	135	136	0	163	156	0.02	0.01	0.00	0.01	0.01
	Alt wag tail	Wag tail while sitting alert; a sign of excitement	559	0.00	559	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Lick object	Licking object (ground, tree/bush, toy, rock)	60	0.27	60	62	60	60	60	0.18	0.13	0.26	0.52	0.28
	Lick self	Licking self	62	1.17	82	80	72	80	62	1.40	1.01	0.94	1.26	1.22
	Alt licking motion	Making a licking motion with tongue while alert	554	0.00	0	0	0	554	0	0.00	0.00	0.00	0.01	0.00
	Lick self pt	Licking self while panting	464	0.00	0	0	0	464	0	0.00	0.00	0.00	0.01	0.00
	Sn & lick	Sniffing and licking an object	137	0.00	137	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Open mouth	Opening mouth but not yawning	339	0.01	507	491	339	0	0	0.01	0.01	0.01	0.00	0.00
	Chew obj	Chewing an object	48	1.77	52	48	49	77	49	1.14	1.79	1.81	2.79	1.30
	Alt chew obj	Chewing something while sitting (sit1) alert	105	0.01	150	0	105	0	136	0.01	0.00	0.03	0.00	0.01
	Sn & chew	Sniffing and chewing an object while in sit1	134	0.03	146	134	0	0	0	0.01	0.16	0.00	0.00	0.00
	Bite obj	Biting an object while sitting	59	0.09	96	108	59	93	59	0.16	0.01	0.15	0.09	0.04
	Bite at other	Bite at other; not Ag because there was no growl or other sign of Ag	99	0.01	106	485	108	99	0	0.03	0.01	0.01	0.02	0.00
	Bite other	Same as above but actually grabbing hold of another Coyote	42	0.01	42	0	0	97	0	0.02	0.00	0.00	0.03	0.00
	Sn & bite	Sniffing then biting something while sitting (e.g., grass/twigs)	100	0.01	0	100	0	0	0	0.00	0.04	0.00	0.00	0.00
	Stretch	Stretching while in sit1 position	118	0.02	126	542	118	133	0	0.01	0.01	0.01	0.04	0.00
	Stretch & yawn	Same as above with yawning	123	0.00	0	0	0	123	0	0.00	0.00	0.00	0.01	0.00
	Stretch chew obj	Stretch and chewing something while in sit1 position	137	0.00	0	0	137	0	0	0.00	0.00	0.01	0.00	0.00
	Scratch self	Scratching self in sit1 position	93	0.06	122	100	110	93	143	0.05	0.05	0.09	0.06	0.04
	Scratch lick self	Scratching and licking self in sit1 position	49	0.00	49	0	0	0	55	0.01	0.00	0.00	0.00	0.01
	Rub head	Rubbing head against ground or an object while sitting	150	0.01	150	0	157	158	415	0.01	0.00	0.01	0.01	0.02
	Head shake	Shaking head (e.g., if wet) while sitting	59	0.03	59	536	96	80	527	0.03	0.01	0.03	0.07	0.02
	Paw/dig	Paw or dig at ground while sitting	96	0.01	114	105	96	99	0	0.01	0.01	0.02	0.01	0.00
	Sn & paw obj	Sniffing and pawing at something while sitting	408	0.00	408	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Pull obj	Pulling something with mouth while sitting	59	0.00	59	0	0	0	0	0.02	0.00	0.00	0.00	0.00
	Look ar	Not focused on any object; moving head to see different things	49	0.59	59	59	74	73	49	0.62	0.22	0.41	0.78	0.93
	Look ar pt	Same as above while panting	108	0.07	490	464	108	410	410	0.03	0.03	0.11	0.03	0.13
	Whine	Whining/whimpering while sitting1	43	0.00	0	48	0	43	0	0.00	0.01	0.00	0.01	0.00
	Swat flies	Swatting bugs out of annoyance (e.g, not self play) while sitting	149	0.00	149	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Woof	Sit1 position and alertly making a warning woof-like call	85	0.00	0	0	85	0	0	0.00	0.00	0.01	0.00	0.00
SIT1	N = 54	Total percentage for SIT1:		11.96						10.89	9.10	9.14	17.73	12.78
SIT2		Sitting on back legs (rear haunches); front legs up in standing-like position	88	0.05	102	88	98	115	140	0.04	0.08	0.04	0.05	0.02
	Sniff	Sniffing in sit2 position	96	0.04	146	109	96	97	99	0.02	0.01	0.01	0.05	0.11
	Pant (pt)	Panting but not focused on anything (eyes open) while sitting	118	0.00	0	0	339	147	118	0.00	0.00	0.01	0.01	0.01
	Alt	Focused on something while sitting	96	0.67	96	105	100	97	97	0.31	0.64	0.59	0.71	1.12

	Alt pt	Same as above while panting	97	0.05	150	513	407	106	97	0.05	0.03	0.06	0.07	0.03
	Alt sn	Sniffing something (usually air) while alert in sit2 position	214	0.00	0	0	0	214	0	0.00	0.00	0.00	0.01	0.00
	I open	Sitting and not focused on anything but eyes open	102	0.00	102	0	0	0	0	0.02	0.00	0.00	0.00	0.00
	I open pt	Same as above while panting	551	0.00	0	551	0	0	0	0.00	0.01	0.00	0.00	0.00
	Lick self	Licking self while sitting	103	0.16	114	134	113	129	103	0.05	0.10	0.13	0.10	0.41
	Lick object	Licking an object while in sit2 position	99	0.01	102	0	0	99	0	0.01	0.00	0.00	0.02	0.00
	Move head	Quickly moving head while sitting	534	0.00	534	551	0	0	0	0.01	0.01	0.00	0.00	0.00
	Bite obj	Biting an object while sitting	97	0.00	0	0	0	99	97	0.00	0.00	0.00	0.01	0.01
	Chew obj	Chewing but not really feeding on something while sitting	99	0.08	146	388	110	120	99	0.05	0.01	0.16	0.13	0.04
	Scratch self	Scratch self; the typical dog-like scratch where a hindleg scratches the rib/shoulder region of body	45	0.13	135	45	108	99	103	0.16	0.08	0.13	0.11	0.18
	Look ar	Looking around; not focused on a specific object; sometimes exaggerated head movement	97	0.10	332	337	331	97	314	0.10	0.09	0.03	0.04	0.22
	Look ar pant	Same as above while panting	413	0.01	469	413	462	486	0	0.02	0.01	0.01	0.01	0.00
	Yawn	Yawning in sit2 position	267	0.01	0	267	311	376	311	0.00	0.01	0.02	0.01	0.01
	Whine	Whining; looking down; not focused on anything in particular	492	0.00	0	0	0	0	492	0.00	0.00	0.00	0.00	0.01
	Alt woof/bark	Giving a warning woof-like call/bark while sit2 position	304	0.00	0	0	304	0	0	0.00	0.00	0.01	0.00	0.00
	Howl	Howling in sit2 position	429	0.01	0	0	429	0	0	0.00	0.00	0.05	0.00	0.00
	Fake howl	Lifting head like howling but producing no sound	484	0.00	0	0	484	0	0	0.00	0.00	0.01	0.00	0.00
	Dig	Digging while in SIT2 position	519	0.00	0	0	0	519	0	0.00	0.00	0.00	0.01	0.00
	Sn dig	Sniffing and digging while in sit2 position	519	0.00	0	0	0	519	0	0.00	0.00	0.00	0.01	0.00
SIT2	N = 23	Total percentage for sit2:		1.34						0.84	1.09	1.25	1.35	2.16
Standing (ST)		Standing and performing behaviors that could not fit into other categories	33	0.42	33	34	34	34	33	0.43	0.33	0.44	0.48	0.45
	Doze	Dozing while in a standing position	301	0.00	0	0	0	0	301	0.00	0.00	0.00	0.00	0.01
	Eyes closed	Eyes closed while standing; often done in hot weather	344	0.00	0	344	0	0	0	0.00	0.01	0.00	0.00	0.00
	Eyes open	Eyes open but not focused on anything in particular while standing	361	0.00	361	0	0	0	396	0.01	0.00	0.00	0.00	0.01
	I open pt	Same as above while panting	479	0.00	0	479	497	0	0	0.00	0.01	0.01	0.00	0.00
	Pt I open hd down	Head facing down while standing and panting	466	0.00	0	0	466	0	0	0.00	0.00	0.01	0.00	0.00
	Blink	Blinking eyes while standing	301	0.01	0	0	0	0	301	0.00	0.00	0.00	0.00	0.03
	Yawn	Yawning while standing	174	0.07	272	267	177	174	234	0.06	0.15	0.06	0.04	0.06
	Yawn alt	Yawning while alert and standing	367	0.00	0	367	0	0	555	0.00	0.01	0.00	0.00	0.01
	Yawn wag tail	Yawning and wagging tail implying excitement	337	0.00	0	337	0	0	0	0.00	0.01	0.00	0.00	0.00
	Cough	Coughing while standing	78	0.01	0	149	561	531	78	0.00	0.01	0.01	0.01	0.01
	Pant (pt)	Panting but not really focusing on anything	94	0.01	0	380	108	102	94	0.00	0.01	0.01	0.01	0.04
	Alert (alt)	Focusing on something	34	7.70	38	37	40	34	39	8.57	8.76	5.08	7.50	8.58
	Alt pant	Alert while panting	92	0.75	114	92	100	102	94	0.52	0.95	0.95	0.42	0.92
	Alt wag tail	Wagging tail while alert, implying some level of excitement; usually around other Coyotes	54	0.14	171	170	528	54	304	0.14	0.20	0.04	0.29	0.06
	Alt wag tail pt	Same as above while panting	427	0.02	427	427	0	531	575	0.01	0.01	0.00	0.05	0.01
	Alt pt tail up	Tail high while standing alert and panting	297	0.00	0	0	0	0	297	0.00	0.00	0.00	0.00	0.01
	Alt tail tucked	Standing alert with tail tucked between legs; sign of submissiveness	582	0.00	0	582	0	0	0	0.00	0.01	0.00	0.00	0.00
	Alt whine	Focused on something and whining	316	0.01	0	0	316	0	0	0.00	0.00	0.03	0.00	0.00

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
Alt whine wag tail	Same as above while wagging tail; Coyote appears anxious; socially related	380	0.00	0	380	0	0	0	0.00	0.01	0.00	0.00	0.00
Lick self	Grooming licking self	55	0.60	111	62	78	70	55	0.43	0.92	0.47	0.61	0.57
Lick coy	Briefly licking another Coyote but not grooming so not infantile behaviour	72	0.01	527	399	72	299	285	0.01	0.01	0.01	0.01	0.03
Lick object	Licking an object while standing	65	0.11	65	156	98	186	123	0.06	0.03	0.03	0.30	0.14
Chew obj	Chewing an object while standing	44	2.78	47	47	47	58	44	2.24	2.33	2.93	2.83	3.59
Chew alt	Same as above while alert	122	0.01	177	290	122	0	0	0.01	0.01	0.01	0.00	0.00
Chew wag tail	Chewing something while wagging tail; excitement evident	430	0.00	430	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Bite obj	Bite at an object, like a branch, while standing	43	0.48	50	45	67	43	45	0.44	0.49	0.35	0.51	0.60
Bite obj hind legs	Bite at an object while standing on hindlegs	147	0.01	0	147	0	0	0	0.00	0.03	0.00	0.00	0.00
Hind legs bite coy	Making general (not Ag) bites at another Coyote while standing on hindlegs	390	0.00	0	390	0	0	0	0.00	0.01	0.00	0.00	0.00
Stretch	Stretching body while standing	59	0.14	59	136	128	77	62	0.07	0.04	0.18	0.29	0.09
Alt & stretch	Same as above while alert	94	0.00	0	0	0	0	94	0.00	0.00	0.00	0.00	0.01
Stretch yawn	Yawning while stretching	177	0.01	214	0	177	303	0	0.01	0.00	0.03	0.01	0.00
Stretch urinate	Stretching and squat-urinating at same time while standing	367	0.00	0	0	0	367	0	0.00	0.00	0.00	0.01	0.00
Rub body	Rubbing body against an object (fence, tree) in standing position	81	0.18	126	153	134	97	81	0.03	0.09	0.31	0.20	0.25
Scratch	Scratching self while standing	45	0.02	379	453	134	67	45	0.03	0.04	0.01	0.02	0.02
Shake body	Shaking body – to dry or get dust off self	37	0.12	38	37	43	45	39	0.13	0.11	0.11	0.12	0.14
Shake head	Twist or shake just the head and neck	149	0.04	527	528	429	295	149	0.03	0.07	0.06	0.03	0.02
Paw object	Pawing at something halfheartedly; not really investigating	142	0.00	0	0	0	142	0	0.00	0.00	0.00	0.02	0.00
Hold object	Holding something in mouth while standing	111	0.02	111	143	122	138	136	0.01	0.01	0.02	0.03	0.01
Drop object	Releasing an object from mouth while standing	338	0.00	0	0	0	499	338	0.00	0.00	0.00	0.01	0.01
Defecate	Defecating, in a squatting position	37	0.12	44	43	38	37	65	0.16	0.15	0.10	0.08	0.11
St b/r	General term for going to bathroom; then divided into urinate and defecate	35	0.01	35	45	44	52	0	0.01	0.01	0.03	0.02	0.00
Urinate	Urinating by leaning forward or standing	34	0.12	38	37	40	34	39	0.10	0.07	0.04	0.22	0.17
FLU	Flex leg urination; flexing forward and partially lifting a hindleg	499	0.02	527	499	512	531	505	0.02	0.04	0.02	0.01	0.01
RLU	Raised leg urination; lifting a hindleg	303	0.00	0	0	0	303	0	0.00	0.00	0.00	0.02	0.00
Alt hindlegs	Standing alert while on hindlegs (looking like a standing human)	58	0.03	430	73	64	58	112	0.01	0.03	0.02	0.07	0.01
Over others	Standing over another Coyote but not really looking at anything; no aggression seen – head alertness not noted	34	0.09	39	34	49	38	185	0.29	0.06	0.01	0.07	0.03
Over others alt	Same as above while focused on something	317	0.04	317	525	402	0	0	0.20	0.01	0.01	0.00	0.00
Over alt pt	Same as above while panting	512	0.00	0	518	512	0	0	0.00	0.01	0.01	0.00	0.00
Over coy hd down	Same as above while head is down (not focused on anything)	534	0.00	534	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Over coy head down pt	Same as above while panting	464	0.01	0	464	512	0	0	0.00	0.01	0.01	0.00	0.00
Over coy look ar	Same as above while looking around	498	0.01	498	0	0	0	0	0.03	0.00	0.00	0.00	0.00
Alt body low wag tail	Standing alert with body low while wagging tail; nervous behaviour of submissive Coyotes	380	0.00	0	380	0	0	0	0.00	0.01	0.00	0.00	0.00
Vomit	Convulsing/throw up while standing	110	0.03	126	0	0	115	110	0.05	0.00	0.00	0.03	0.05

	Sneeze	Sneezing in a standing position	225	0.00	443	0	225	0	532	0.01	0.00	0.01	0.00	0.01
	Whine	Whining; not really looking around but eyes open	34	0.23	35	34	34	34	35	0.13	0.11	0.38	0.43	0.11
	Bark/woof	Woof-barking (warning call) at something (usually a person)	27	0.03	0	420	185	27	59	0.00	0.06	0.06	0.02	0.01
	Alt bark/woof	Same as above while alert	225	0.03	0	569	225	236	0	0.00	0.01	0.15	0.01	0.00
	Howl alone	Lone howl while standing	33	0.07	35	34	34	34	33	0.01	0.16	0.17	0.01	0.03
	Bark howl	Bark howl while standing	38	0.00	38	0	417	0	0	0.01	0.00	0.01	0.00	0.00
	Howl & whine	Howling and whining while standing	38	0.00	0	0	38	0	0	0.00	0.00	0.01	0.00	0.00
	Howl group	Group howl while standing	34	0.02	0	390	417	34	401	0.00	0.04	0.02	0.03	0.02
	Fake howl	Going through howling motion but no sound produced	44	0.02	0	44	423	0	0	0.00	0.07	0.06	0.00	0.00
	Step	Stepping to one side with front legs	548	0.01	559	562	0	548	549	0.01	0.01	0.00	0.02	0.01
	Step alt	Same as above but while alert – usually done to get a better view	547	0.01	0	547	561	0	0	0.00	0.03	0.01	0.00	0.00
ST	N = 67	Total percentage for St:		14.62						14.28	15.53	12.28	14.83	16.21
Traveling (T)		Traveling; moving with purpose from point A to B	27	0.74	35	34	34	27	33	0.67	0.44	0.82	0.73	1.03
	Walk (Wk)	Walking – slow movement when lateral legs move together; two legs always on the ground	43	2.42	75	48	43	51	68	3.16	2.29	2.01	2.45	2.19
	Wk pant (pt)	Walking and panting	106	0.24	117	112	119	106	107	0.25	0.23	0.12	0.22	0.41
	Wk alt	Walking and focused on something ahead	47	2.70	93	105	71	73	47	3.17	2.77	2.47	1.98	3.12
	Wk alt pt	Same as above while panting	94	0.21	98	194	181	148	94	0.20	0.17	0.15	0.16	0.36
	Wk wag tail	Walking and wagging tail; looks excited – almost greet SuA	170	0.02	302	170	0	0	540	0.03	0.06	0.00	0.00	0.01
	Wk alt wag tail	Same as above while alert	214	0.01	214	344	402	0	311	0.02	0.01	0.01	0.00	0.02
	Wk alt pt wag tail	Same as above while panting	531	0.00	0	0	0	531	0	0.00	0.00	0.00	0.01	0.00
	Wk whine	Whining while walking	148	0.00	0	0	365	0	148	0.00	0.00	0.01	0.00	0.01
	Wk alt whine	Walking and alert while whining	324	0.00	0	0	0	324	0	0.00	0.00	0.00	0.01	0.00
	Wk bark/woof	Walking and giving a warning call while looking down	277	0.00	0	431	277	0	0	0.00	0.01	0.01	0.00	0.00
	Wk alt woof	Same as above while alert	298	0.02	0	0	298	0	311	0.00	0.00	0.07	0.00	0.01
	Howl gr & wk	Walking and group howling	429	0.00	0	528	429	0	0	0.00	0.01	0.01	0.00	0.00
	Wk fake howl	Walking and making a howl-like motion but no sound produced	561	0.00	0	0	561	0	0	0.00	0.00	0.01	0.00	0.00
	Wk w/ object	Walking with object in mouth	50	0.08	50	149	154	91	149	0.14	0.04	0.09	0.12	0.04
	Wk chew obj	Walking and chewing on something	122	0.03	122	143	132	142	143	0.04	0.02	0.07	0.03	0.01
	Wk drag obj	Walking and dragging a large object like a branch	47	0.01	0	50	47	0	0	0.00	0.02	0.02	0.00	0.00
	Wk scratch/rub	Walking and rubbing body against object (fence, branch)	316	0.00	0	0	316	0	0	0.00	0.00	0.01	0.00	0.00
	Wk stretch	Walking and stretching	133	0.00	0	0	0	133	0	0.00	0.00	0.00	0.01	0.00
	Wk wh wag tail	Walking and whining while wagging tail; nervous	365	0.00	0	0	365	0	0	0.00	0.00	0.01	0.00	0.00
	Wk wag body	Walking and wagging body; very excited but not directed at a Coyote	373	0.00	0	373	0	0	0	0.00	0.01	0.00	0.00	0.00
	Wk shake self	Walking and shaking body; usually done when wet	132	0.01	294	0	132	295	297	0.01	0.00	0.02	0.01	0.01
	Wk body low	Walking with body low; done by submissive Coyotes	362	0.02	0	362	386	0	0	0.00	0.06	0.02	0.00	0.00
	Wk bod low wg tl	Walking with body low and wagging tail SuA like but done to no Coyote	375	0.00	0	375	0	0	0	0.00	0.01	0.00	0.00	0.00
	Wk limp	Limping while walking	45	0.00	0	45	0	0	0	0.00	0.01	0.00	0.00	0.00
	Wk yawn	Walking and yawning	147	0.02	390	147	522	186	268	0.01	0.04	0.01	0.01	0.03
	A wk	Approaching a Coyote or human while walking	34	0.02	541	506	34	109	92	0.01	0.02	0.04	0.03	0.02
	Wk follow	Walking while purposely following another Coyote(s)	99	0.06	332	275	346	99	241	0.03	0.06	0.09	0.07	0.06
	Wk defecate	Defecating while walking	518	0.00	0	0	518	0	0	0.00	0.00	0.01	0.00	0.00

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
A wk limp	Approaching a Coyote while walking with a limp	43	0.00	0	43	0	0	0	0.00	0.01	0.00	0.00	0.00
Trot	Trotting while looking down; not focused on anything; going the equivalent of jogging pace for humans (includes loping and cantering) where left front and right rear legs touch ground at same time, and vice versa	48	1.84	80	77	48	80	48	1.93	2.18	1.61	1.28	2.21
Trot pt	Trotting and panting while looking down	107	0.14	122	174	119	135	107	0.10	0.16	0.18	0.11	0.14
Trot alt	Trotting and focused on something	88	1.49	135	124	88	135	129	1.89	1.33	1.70	0.87	1.69
Trot alt pant	Same as above while panting	394	0.12	413	469	417	410	394	0.07	0.03	0.27	0.05	0.18
Trot tail high	Trotting with tail high; done by a confident, more dominant Coyote	236	0.00	236	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Trot alt tail high	Same as above while alert	250	0.00	0	250	0	0	0	0.00	0.01	0.00	0.00	0.00
Trot wag tail	Wagging tail while trotting; sign of excitement	257	0.01	0	257	0	0	0	0.00	0.03	0.00	0.00	0.00
Trot alt wag tail	Trotting and alert while wagging tail	375	0.01	469	375	550	0	0	0.01	0.01	0.01	0.00	0.00
Trot pt wag tail	Trotting and panting while wagging tail	453	0.00	0	453	0	0	0	0.00	0.01	0.00	0.00	0.00
Trot whine	Trotting and whining; clearly anxious about something	344	0.01	0	344	374	0	0	0.00	0.01	0.02	0.00	0.00
Trot alt whine	Trotting alertly while whining	379	0.00	0	0	379	0	0	0.00	0.00	0.02	0.00	0.00
Trot alt woof	Trotting alertly while barking at something, usually human	235	0.02	0	536	235	341	338	0.00	0.01	0.06	0.01	0.01
Trot tail low	Trotting with tail low; social implications (subordination)	373	0.00	0	373	0	0	0	0.00	0.01	0.00	0.00	0.00
Trot body low	Trotting with whole body low; social subordination	44	0.01	44	373	462	0	44	0.01	0.05	0.01	0.00	0.01
Trot yawn	Trotting and yawning	365	0.00	452	0	365	0	429	0.01	0.00	0.01	0.00	0.01
Trot with obj	Trotting with object in mouth	126	0.06	145	156	150	126	136	0.07	0.04	0.11	0.04	0.03
Gr trot	Trotting as a group (with ≥2 others) from one place to another	109	0.02	236	448	365	109	170	0.02	0.01	0.01	0.01	0.03
Trot follow	Trotting and following other Coyote(s)	59	0.11	59	124	74	97	107	0.04	0.08	0.17	0.07	0.19
Trot follow coy pt	Same as above while panting	469	0.01	469	0	497	0	527	0.01	0.00	0.02	0.00	0.02
Trot follow me	Following JGW at a trot while he moves	59	0.00	0	59	0	0	0	0.00	0.01	0.00	0.00	0.00
A trot	Approach human (JGW) or Coyote at a trot	27	0.59	38	34	39	27	33	0.67	0.70	0.49	0.45	0.63
A trot gr	Approach group at a trot	221	0.00	0	221	0	221	0	0.00	0.01	0.00	0.01	0.00
Run	Moving at a fast pace; body stretched out; not focused on anything; all four legs often in the air	33	0.33	33	45	44	44	45	0.39	0.32	0.43	0.22	0.29
Run alt	Running while alert – focused on something	165	0.03	294	167	235	193	165	0.03	0.01	0.07	0.01	0.05
Run alt pt	Running while alert and panting	423	0.00	0	0	423	0	0	0.00	0.00	0.01	0.00	0.00
Run alt woof	Running and alert while barking at something	341	0.00	0	0	0	341	0	0.00	0.00	0.00	0.01	0.00
Run with obj	Running with object in mouth	194	0.00	0	194	0	0	0	0.00	0.01	0.00	0.00	0.00
Run howl	Running and howling at same time	362	0.00	0	0	0	362	0	0.00	0.00	0.00	0.01	0.00
Run body low	Running with body low; social subordination	344	0.00	0	344	0	0	0	0.00	0.01	0.00	0.00	0.00
Run tail tucked	Running with tail tucked; social subordination	181	0.00	0	413	181	0	0	0.00	0.01	0.01	0.00	0.00
Run follow	Running while following another Coyote(s); no interactions taking place with that Coyote	47	0.01	340	0	105	0	47	0.01	0.00	0.02	0.00	0.02
A run	Approaching something at a run	91	0.01	0	0	167	91	285	0.00	0.00	0.01	0.01	0.01
Flee	Reflex-like response of running away from something	73	0.00	0	0	0	73	0	0.00	0.00	0.00	0.01	0.00

T	N = 63	Total percentage for T:		11.50					12.99	11.32	11.32	9.02	12.85
Export/Investigate (E/I)		Exploring/investigating surroundings; moving in a non-direct manner	27	7.10	33	34	34	27	33	7.69	6.12	6.78	7.76	7.13
	Pt	General e/i behaviour while panting	94	0.00	0	0	0	0	94	0.00	0.00	0.00	0.00	0.01
	Stand (st) sn	Standing and sniffing something (ground, tree, branch)	33	8.12	49	37	51	34	33	8.83	7.86	7.98	7.11	8.85
	St sn & alt	Standing and sniffing (usually the air) something while alert	34	0.02	120	0	128	34	118	0.05	0.00	0.01	0.01	0.01
	St sn pt	Standing and sniffing something while panting	151	0.01	0	0	0	486	151	0.00	0.00	0.00	0.01	0.03
	St sn stretch	Standing and sniffing something while stretching	172	0.00	0	0	0	172	0	0.00	0.00	0.00	0.01	0.00
	St sn wag tail	Standing and sniffing while wagging tail; excitement indicated	214	0.01	214	518	0	548	486	0.01	0.01	0.00	0.01	0.01
	St sn urinate	Standing and sniffing while urinating	82	0.00	0	257	0	82	0	0.00	0.01	0.00	0.01	0.00
	St sn whine	Standing and sniffing while whining (anxiety)	397	0.00	0	0	397	0	0	0.00	0.00	0.01	0.00	0.00
	St sn Coyote	Standing and sniffing another Coyote	80	0.15	80	96	132	82	123	0.14	0.22	0.09	0.19	0.11
	St sn (me)	Standing and sniffing JGW	227	0.00	0	227	0	0	0	0.00	0.01	0.00	0.00	0.00
	St sn gr	Standing and sniffing as a group	88	0.01	181	127	88	178	110	0.01	0.01	0.03	0.01	0.01
	St sn & bite	Standing and sniffing something while biting an object	121	0.01	0	121	122	0	129	0.00	0.01	0.03	0.00	0.01
	St sn & chew	Standing and sniffing something while chewing on an object	85	0.02	85	0	0	537	0	0.07	0.00	0.00	0.02	0.00
	St sn & pull at	Standing and sniffing something while pulling on an object	142	0.00	142	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Hind legs	Investigate something on hind legs	59	0.10	60	64	59	62	59	0.10	0.06	0.09	0.09	0.16
	Sn hind legs	Sniff something on hind legs	52	0.05	52	62	59	53	123	0.05	0.06	0.01	0.05	0.06
	Look around (ar)	Looking around; usually standing but sometimes involves moving around (stepping) slowly from side-to-side	34	2.46	42	53	81	34	59	3.13	2.13	2.09	2.20	2.77
	Look ar pant	Same as above while panting	406	0.53	413	413	407	410	406	0.31	0.49	0.94	0.39	0.54
	Look ar tail up	Looking around with tail up; a sign of dominance	528	0.00	0	0	528	0	0	0.00	0.00	0.01	0.00	0.00
	Look ar wag tail	Same as above while wagging tail	318	0.04	413	453	550	318	532	0.03	0.05	0.01	0.07	0.04
	Look ar wag tail pt	Looking around while wagging tail and panting	413	0.01	0	413	0	519	0	0.00	0.01	0.00	0.04	0.00
	Look ar sneeze	Looking around and sneezing	541	0.00	0	0	541	0	0	0.00	0.00	0.01	0.00	0.00
	Look ar whine	Looking around and whining	518	0.01	0	0	518	0	0	0.00	0.00	0.03	0.00	0.00
	Step sn	Stepping to side with front legs while sniffing; formerly classified as wk sn but documented more often after this study	564	0.00	564	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Walk (wk) around	Walking around with no apparent direction in mind; usually looking at different things while walking	59	5.23	59	85	60	70	59	5.07	6.79	6.34	3.68	4.30
	Wk ar pant	Same as above while panting	339	0.79	413	413	339	410	410	0.59	1.23	1.01	0.48	0.67
	Wk ar yawn	Same as above while panting	499	0.00	0	499	0	0	0	0.00	0.01	0.00	0.00	0.00
	Wk ar wag tail	Walking around and wagging tail indicating excitement	302	0.08	302	344	379	414	483	0.07	0.22	0.04	0.02	0.04
	Wk ar pt wag tail	Same as above while panting	469	0.01	0	469	0	531	0	0.00	0.01	0.00	0.02	0.00
	Wk ar body low	Walking around with body low; social subordination	399	0.01	0	399	451	0	0	0.00	0.06	0.01	0.00	0.00
	Wk ar limp	Walking around and limping on a leg	43	0.00	0	43	0	0	0	0.00	0.01	0.00	0.00	0.00
	Wk ar whine	Walking around while whining; implying anxiousness	339	0.02	0	413	339	0	0	0.00	0.01	0.07	0.00	0.00
	Wk ar whin tl high	Walking around while whining but tail high; confusion apparent where Coyote whines but has tail up indicating confidence	518	0.00	0	0	518	0	0	0.00	0.00	0.01	0.00	0.00
	Wk ar & woof	Walk around and make warning calls	368	0.00	0	431	368	0	0	0.00	0.01	0.01	0.00	0.00
	Wk and look ar	Exaggerated movements of looking everywhere while walking around.	94	0.05	120	131	141	526	94	0.01	0.04	0.01	0.02	0.15

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
Wk ar group (gr)	Walking around in a group (>2 others) setting; social interactions implied but nothing specific happening	281	0.02	281	479	484	0	0	0.01	0.04	0.05	0.00	0.00
Wk sn	Walking and sniffing the ground	82	4.20	98	109	88	82	87	3.40	4.50	5.95	3.19	4.03
Wk sn Coyote	Walking and sniffing another Coyote	508	0.00	0	547	0	0	508	0.00	0.01	0.00	0.00	0.01
Wk sn pt	Walking and sniffing while panting	464	0.01	469	464	466	0	0	0.01	0.01	0.04	0.00	0.00
Wk sn wag tail	Same as above while wagging tail (excitement)	408	0.00	408	0	550	0	0	0.01	0.00	0.01	0.00	0.00
Wk sn whine	Same as above while whining (anxious)	368	0.01	0	0	368	0	0	0.00	0.00	0.03	0.00	0.00
Wk sn gr	Walking in sniffing with (≥2 others	103	0.00	0	0	0	0	103	0.00	0.00	0.00	0.00	0.01
Trot around (ar)	Trotting around with no apparent direction	129	0.88	257	227	144	295	129	0.65	1.14	1.72	0.33	0.60
Trot ar pant	Same as above while panting	406	0.19	463	413	417	410	406	0.05	0.08	0.68	0.03	0.14
Trot ar tail low	Same as above with tail low; submissiveness indicated	420	0.00	0	420	0	0	0	0.00	0.01	0.00	0.00	0.00
Trot ar tail tucked	Same as above with tail tucked; submissiveness indicated	582	0.00	0	582	0	0	0	0.00	0.01	0.00	0.00	0.00
Trot ar pt tail high	Same as above with tail high; dominance indicated	545	0.00	0	0	545	0	0	0.00	0.00	0.01	0.00	0.00
Trot ar wh tl high	Trotting around while whining but tail high; confusion apparent where Coyote whines but has tail up indicating confidence	518	0.00	0	0	518	0	0	0.00	0.00	0.01	0.00	0.00
Trot ar wag tail	Same as above while wagging tail	344	0.03	413	344	545	0	532	0.03	0.11	0.01	0.00	0.01
Trot ar wg tail eee	Same as above while making the shreel-like sound	544	0.00	544	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Trot ar body low	Same as above with body low	399	0.01	0	399	0	0	0	0.00	0.06	0.00	0.00	0.00
Trot ar whine	Trotting around while whining	411	0.02	0	0	411	0	0	0.00	0.00	0.08	0.00	0.00
Trot ar pt whine	Same as above while panting	477	0.00	0	0	477	0	0	0.00	0.00	0.01	0.00	0.00
Trot sn	Trotting and sniffing ground	125	0.21	162	141	125	178	148	0.07	0.11	0.66	0.02	0.19
Trot sn pant	Trotting and sniffing while panting	417	0.00	0	0	417	0	0	0.00	0.00	0.01	0.00	0.00
Trot sn whine	Trotting and sniffing while whining	541	0.00	0	0	541	0	0	0.00	0.00	0.01	0.00	0.00
Run around	Running around; random cutting and zigzagging across exhibit	411	0.02	0	0	411	0	505	0.00	0.00	0.06	0.00	0.01
Run ar pt	Running around and panting	477	0.00	0	0	477	0	0	0.00	0.00	0.01	0.00	0.00
Run sniff	Running and sniffing the ground	423	0.00	0	0	423	0	0	0.00	0.00	0.01	0.00	0.00
Circling	Moving around in a circular motion	65	0.00	65	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Dig/paw	Digging or pawing at an object; very active with paws	34	0.33	44	42	38	34	35	0.22	0.40	0.55	0.31	0.15
Paw on hind legs	Same as above on hind legs	59	0.00	0	0	0	59	0	0.00	0.00	0.00	0.01	0.00
Dig pt	Same as above while panting	466	0.00	0	0	466	0	0	0.00	0.00	0.01	0.00	0.00
Dig/paw sniff	Same as above while sniffing standing or crouched (forelegs low)	91	0.28	117	105	93	91	118	0.31	0.28	0.34	0.37	0.11
Dig & bite	Dig and bite at an object (e.g., roots)	96	0.01	96	0	0	0	0	0.04	0.00	0.00	0.00	0.00
Dig & chew	Dig and chew on an object (e.g., sticks)	125	0.01	0	0	125	0	0	0.00	0.00	0.03	0.00	0.00
Cache	Burying an object (e.g., carcass) usually using nose to push dirt over object	39	0.03	49	0	39	341	0	0.03	0.00	0.04	0.06	0.00
Cache & whine	Same as above while whining	39	0.00	0	0	39	0	0	0.00	0.00	0.01	0.00	0.00
Push obj	Pushing an object with feet or nose	367	0.00	0	0	0	367	0	0.00	0.00	0.00	0.01	0.00
Pull obj	Pulling/dragging (walking backwards) something like a branch	47	0.07	68	62	47	58	0	0.06	0.10	0.03	0.16	0.00
Whine	General exploring behavior while whining; indicting anxious/nervousness	39	0.01	0	53	43	39	0	0.00	0.01	0.01	0.02	0.00

E&I	N = 72	Total percentage for E/I:		32.23					31.07	32.30	36.0	26.71	30.18
Hunting (HU)		Hunting behavior; actively trying to catch or kill an object; it was difficult to distinguish between a Coyote's behavior/intentions/body language when hunting mice or stalking conspecifics so they are merged together	49	0.02	59	73	122	237	49	0.02	0.01	0.01	0.01	0.04
	Dig/paw	Pawing/batting (with paw) at something like a mouse	241	0.01	261	0	277	0	241	0.01	0.00	0.01	0.00	0.05
	Paw stab	Trying to stab something with quick paw movements	260	0.01	0	0	260	367	382	0.00	0.00	0.01	0.01	0.01
	Bite (air)	Biting air while typically trying to catch birds in flight	106	0.00	0	0	277	106	0	0.00	0.00	0.01	0.01	0.00
	Jump	Jumping at prey, mostly birds in flight	228	0.00	0	0	270	0	228	0.00	0.00	0.01	0.00	0.01
	Pounce	Jumping up and landing on prey (e.g., mousing)	176	0.01	261	0	198	0	176	0.01	0.00	0.01	0.00	0.02
	Ambush-crouch sit1	Intently watching Coyote or prey while hiding in sit1 Alt position (body near ground); body tense; ears pricked forward, eyes locked on target	469	0.00	469	0	0	0	0	0.01	0.00	0.00	0.00	0.00
	Amb-cr sit2	Same as above but in sit2 position	391	0.00	0	0	0	391	532	0.00	0.00	0.00	0.01	0.01
	Ambush-crouch St	Same as above but in a standing position	40	0.10	40	48	51	102	48	0.06	0.08	0.19	0.06	0.08
	Ambush-stalk	Creeping up on a Coyote or prey; body still very tense; ears pricked forward	39	0.24	39	43	51	58	43	0.26	0.18	0.24	0.11	0.42
	Ambush-rush	Running towards prey/Coyote; context not always clear when after a Coyote (e.g., initiating play, practicing hunting, disciplining other)	39	0.04	39	40	125	178	43	0.02	0.04	0.01	0.10	0.05
	Chase (prey)	Full speed chase to catch prey	106	0.10	226	167	213	106	170	0.10	0.05	0.06	0.07	0.20
	N = 12	Total percentage for HU:		0.53						0.48	0.36	0.55	0.38	0.89
Feeding (FE)		Feeding; ingesting something	27	1.16	33	34	34	27	39	1.03	1.19	1.15	1.39	1.05
	Alt	Standing alert while feeding; usually while standing	129	0.00	0	0	0	0	129	0.00	0.00	0.00	0.00	0.01
	Sit1	Feeding while in sit1 position	77	0.00	0	0	0	77	0	0.00	0.00	0.00	0.01	0.00
	Grass	Eating grass - standing	35	0.14	35	39	40	42	52	0.13	0.11	0.13	0.18	0.14
	Grass sit1	Eating grass – in sit1	54	0.00	54	0	0	97	0	0.01	0.00	0.00	0.01	0.00
	Dog chow	Eating dog food (dry chow); usually while standing	33	0.59	33	50	48	60	65	0.53	0.45	0.99	0.43	0.53
	Meat	Eating meat (supplied by zookeepers); usually while standing	33	0.03	33	194	0	34	39	0.10	0.01	0.00	0.01	0.01
	Carcass	Eating a rat or guinea pig or something they killed; this is most often in sit1	33	0.01	33	42	0	51	0	0.03	0.01	0.00	0.01	0.00
	Bone	Eating a bone – usually the fat on the bone	39	0.13	52	53	48	39	48	0.16	0.06	0.03	0.20	0.18
	Ice	Chewing and eating ice	177	0.01	177	0	0	0	0	0.03	0.00	0.00	0.00	0.00
	Drink	Drinking water; usually while standing	40	0.46	64	40	59	67	44	0.35	0.32	0.85	0.38	0.41
	Misc	Ingesting something (undetermined)	37	0.16	47	37	43	39	39	0.14	0.21	0.08	0.10	0.27
	T walk	Eating (usually dry dog food) while walking	39	0.04	39	47	86	39	79	0.03	0.09	0.01	0.03	0.05
	T run	Eating (usually dry dog food) while running	78	0.00	0	0	78	0	0	0.00	0.00	0.01	0.00	0.00
	N = 14	Total percentage for FE:		2.72						2.53	2.44	3.24	2.75	2.65
Infantile (IN)		Infantile; neonatal (close body) contact and/or licking/ grooming (non-face areas) ≥ 1 other Coyotes	27	0.50	38	37	40	27	39	0.63	0.56	0.34	0.75	0.22
	Resting	Re position on each other clearly for close contact; not really looking at anything; typically was done during rain	37	0.28	50	48	59	37	59	0.31	0.27	0.28	0.17	0.38
	Re sleep	Same as above while sleeping	59	0.01	0	59	0	0	0	0.00	0.03	0.00	0.00	0.00
	Sit1	Same as above but in sit1	119	0.01	0	131	119	0	338	0.00	0.02	0.01	0.00	0.01

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
Sit2	Same as above but in sit2	168	0.01	168	0	0	0	0	0.03	0.00	0.00	0.00	0.00
Stand (St)	Same as above but standing	38	0.02	38	0	368	0	73	0.10	0.00	0.01	0.00	0.01
St alt	Same as above but while alert	168	0.00	168	0	0	0	0	0.01	0.00	0.00	0.00	0.00
St sn	Same as above but while sniffing something (undetermined)	168	0.00	168	0	0	0	0	0.02	0.00	0.00	0.00	0.00
St sn Coyote	Same as above but while sniffing another Coyote	66	0.00	0	66	0	0	0	0.00	0.01	0.00	0.00	0.00
Lick coy	Licking another Coyote while standing up	38	0.21	59	43	43	38	44	0.22	0.29	0.10	0.39	0.04
Lick sit	Same as above but sitting (sit1 or 2 not noted)	85	0.00	0	0	0	85	0	0.00	0.00	0.00	0.01	0.00
Lick sit1	Licking another Coyote while in sit1 position	123	0.07	544	362	0	123	185	0.01	0.06	0.00	0.29	0.01
Lick sit2	Same as above but in sit2	168	0.00	168	0	0	0	0	0.02	0.00	0.00	0.00	0.00
Licked	Getting licked by another Coyote usually standing but sometimes in sit1 position (i.e., position not noted)	133	0.07	168	212	368	133	140	0.07	0.06	0.22	0.01	0.01
Licked sit2	Getting licked by another Coyote while in sit2 position	492	0.00	0	0	0	0	492	0.00	0.00	0.00	0.00	0.01
Licked & wag tail	Same as above but wagging tail	525	0.00	0	525	0	0	0	0.00	0.01	0.00	0.00	0.00
N = 16	Total percentage for IN:		1.20						1.41	1.31	0.96	1.62	0.69
Greet GR)	Neutral to positive social contacts where licking face and muzzle touching occurred; tail wagging is common; characterized by non-agonistic and non-play encounters	34	0.02	39	34	77	39	0	0.03	0.02	0.01	0.03	0.00
Coyote st (coy)	Greeting a Coyote as mentioned above while standing	34	0.53	64	34	34	34	121	0.56	0.70	0.68	0.42	0.30
Coy sit1	Greeting a Coyote as mentioned above while sitting1	72	0.05	146	233	132	72	94	0.03	0.01	0.03	0.13	0.04
Coy sit2	Greeting a Coyote as mentioned above while sitting2	230	0.00	0	0	230	0	555	0.00	0.00	0.01	0.00	0.01
Coy moving	Greeting a Coyote while moving (walking)	185	0.01	498	215	185	362	0	0.01	0.01	0.01	0.01	0.00
Person	Greeting a person (JGW) with the same body movements and behavior	34	0.53	38	34	34	34	35	0.39	0.72	0.49	0.64	0.40
me sit	Greeting a person (JGW) while Coyote is sitting	70	0.00	0	0	0	70	0	0.00	0.00	0.00	0.01	0.00
Me sit2	Greeting a person (JGW) while Coyote is in sit2 position	514	0.00	0	0	0	514	0	0.00	0.00	0.00	0.01	0.00
Me on hindlegs	Greeting a person (JGW) while Coyote is on hindlegs – forelegs up on chest	548	0.00	0	0	0	548	0	0.00	0.00	0.00	0.01	0.00
Person & whine	Greeting a person (JGW) while Coyote is whining	34	0.01	44	34	0	0	0	0.01	0.01	0.00	0.00	0.00
Coy & person	Greeting both people and Coyote(s)	390	0.00	390	0	0	0	0	0.01	0.00	0.00	0.00	0.00
SuA	Active submission where one Coyote comes by in a low (submissive) posture and licks another's muzzle; exaggerated tail wagging is common	33	0.14	33	45	144	115	35	0.14	0.48	0.05	0.01	0.05
SuA group	Where a Coyote does SuA to the group (≥2 others)	134	0.03	544	134	323	0	0	0.01	0.13	0.01	0.00	0.00
SuA whine	Where a Coyote does SuA and whines to another	263	0.00	0	0	263	0	0	0.00	0.00	0.02	0.00	0.00
N = 14	Total percentage for GR:		1.33						1.19	2.08	1.31	1.26	0.81
Play Self (PS)	Self play incorporating many concepts of play; movements are exaggerated and random, wide-eyes, jaws open, lips retracted (play face), appears pleasurable	27	0.84	33	39	38	27	35	0.78	0.58	1.47	0.90	0.49
Gm	General movements such as walking around, moving head and eyes;												

	erratic, clearly having fun	49	0.00	0	0	49	0	0	0.00	0.00	0.01	0.00	0.00
Chase tail	Chasing own tail	55	0.01	498	55	80	0	148	0.01	0.03	0.01	0.00	0.01
head shake	Shaking head exaggeratedly for no apparent other reason	79	0.11	91	92	88	79	160	0.16	0.07	0.13	0.19	0.01
In H2O	Playing, splashing in water	60	0.08	60	64	86	93	486	0.03	0.15	0.05	0.16	0.02
Paw	Pouncing around and pawing at things; appears pleasurable	49	0.06	49	109	51	80	110	0.07	0.04	0.10	0.10	0.01
Paw/hit self	Pawing or hitting self	70	0.00	0	0	0	70	0	0.00	0.00	0.00	0.01	0.00
Tug	Tugging at an object while in self play	54	0.04	54	62	74	62	60	0.03	0.07	0.04	0.04	0.03
Bite air	Biting at air in erratic movements	395	0.00	0	395	0	0	0	0.00	0.01	0.00	0.00	0.00
Bite self	Biting at self in erratic movements	71	0.00	0	0	71	0	0	0.00	0.00	0.01	0.00	0.00
Bite object	Biting at an object in erratic, playful movements	59	0.02	59	59	67	77	0	0.07	0.01	0.01	0.02	0.00
Tear obj	Tear and chewing objects exaggeratedly	91	0.01	91	156	302	158	202	0.01	0.01	0.01	0.01	0.01
Push obj	Pushing objects with wide-eyes, exaggerated movements	221	0.00	0	221	0	391	382	0.00	0.01	0.00	0.01	0.01
Toss obj	Tossing an object (e.g., dead mouse) in air – usually repeatedly done	71	0.19	120	92	96	111	71	0.20	0.27	0.22	0.15	0.13
Head toss	Tossing objects such as food	39	0.00	0	39	171	0	0	0.00	0.01	0.01	0.00	0.00
Pounce obj	Pouncing on non-prey (usually just the ground); appears to be practicing hunting	51	0.03	98	73	51	158	97	0.03	0.05	0.06	0.01	0.02
Run ar	Erratically running around in circles	49	0.02	60	92	49	93	82	0.03	0.01	0.04	0.02	0.01
Roll	Rolling around while exaggerating movements	74	0.03	0	121	74	80	0	0.00	0.01	0.08	0.05	0.00
Jump	Jumping up and down	85	0.01	96	0	85	299	0	0.01	0.00	0.01	0.01	0.00
A/w	Bouncing back and forth almost like it can't decide where to go	53	0.01	192	0	53	93	225	0.01	0.00	0.04	0.01	0.01
N = 20	Total percentage for self-play (PS):		1.50						1.43	1.33	2.32	1.68	0.75
Play Initiation (PI)	Play initiation; actively soliciting play with others; previously not engaged in play before doing PI with a Coyote	27	0.08	33	40	38	27	35	0.12	0.06	0.06	0.08	0.07
Gm	Same as play general movements but trying to initiate play with other(s)	27	0.01	52	0	154	27	0	0.01	0.00	0.01	0.03	0.00
Wag tail	Wagging tail and showing play face to another Coyote(s)	148	0.00	0	161	0	221	148	0.00	0.01	0.00	0.01	0.01
Bow	Front legs low and hind legs up; tail wagging common	39	0.05	39	47	93	39	39	0.07	0.05	0.03	0.07	0.04
Bark	Barking at others often followed by a play bow	78	0.00	0	0	78	0	0	0.00	0.00	0.02	0.00	0.00
SuP	Exaggerated, friendly position with paws in air trying to get another near it	363	0.00	0	0	0	0	363	0.00	0.00	0.00	0.00	0.01
Approach	Approaching another Coyote with play face, usually walking	47	0.01	0	47	0	73	79	0.00	0.01	0.00	0.01	0.01
A/W	Rapidly approaching and withdrawing from a Coyote trying to initiate play with that Coyote	44	0.07	52	47	51	62	44	0.06	0.06	0.10	0.07	0.08
A/w gr	Same as above but in a group	128	0.00	128	0	0	0	0	0.01	0.00	0.00	0.00	0.00
SuA-ea	An exaggerated active submission posture trying to get another to play	45	0.00	0	0	0	0	45	0.00	0.00	0.00	0.00	0.01
Bump other	Deliberately bumping into another to initiate play	85	0.01	0	85	0	106	107	0.00	0.02	0.00	0.01	0.01
Paw	Pawing at another Coyote trying to get it to play	62	0.03	85	62	113	82	97	0.02	0.03	0.03	0.06	0.03
Face paw	Pawing at another in the face	27	0.01	0	0	0	27	0	0.00	0.00	0.00	0.03	0.00
Flaunt with obj	Trotting around with object in mouth trying to get other(s) involved	126	0.00	0	0	141	126	0	0.00	0.00	0.01	0.01	0.00
Bite	Biting another in a playful manner	51	0.04	59	131	51	67	99	0.05	0.04	0.06	0.01	0.03
Bite at/intentions	Biting at another in a playful manner but making no contact	51	0.06	137	153	51	80	68	0.03	0.01	0.08	0.10	0.08
Jump	Jumping in the air near another Coyote	73	0.01	73	124	167	0	0	0.01	0.01	0.01	0.00	0.00
LL	Same as Play LL but trying to solicit play	48	0.01	0	48	59	0	0	0.00	0.01	0.02	0.00	0.00

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
Pounce	Jumping in front of another Coyote	59	0.02	64	77	59	0	0	0.04	0.02	0.04	0.00	0.00
Run around	Running quickly around trying to get others to join the chase	39	0.03	60	79	85	148	39	0.03	0.01	0.01	0.03	0.06
Run w object	Same as above but with something in its mouth	150	0.00	177	0	150	0	0	0.01	0.00	0.01	0.00	0.00
Bite and run	Nipping another playfully then running around	199	0.00	0	0	0	199	0	0.00	0.00	0.00	0.01	0.00
Ch	Chasing a Coyote to try and start a game of chase	47	0.00	0	47	0	0	81	0.00	0.01	0.00	0.00	0.01
Circling	Circling another with play face apparent	75	0.00	0	75	0	102	0	0.00	0.01	0.00	0.01	0.00
N = 24	Total percentage for PI:		0.46						0.46	0.35	0.48	0.54	0.47
Play (P)	Social play; see text for the characteristics of play; exaggerated and unpredictable movements; pleasurable activities; play face apparent	33	1.73	33	34	38	34	33	2.26	1.85	1.14	1.47	1.91
Group (gr)	General group (≥2 Coyotes) play where a lot is happening but one thing doesn't predominate like wrestling or playing	42	0.36	47	42	51	60	47	0.33	0.32	0.47	0.35	0.34
Periphery	Mocking the movements (running, wrestling) of the 2 Coyotes playing; done at the edge (1-2 m away) of the Coyotes	47	0.01	0	0	47	0	0	0.00	0.00	0.07	0.00	0.00
Periphery gr	Same as above but ≥3 of the Coyotes are playing	52	0.01	0	0	52	0	0	0.00	0.00	0.07	0.00	0.00
Gm	General movements such as walking around others, moving head and eyes; erratic movements; basically, play was occurring but it was hard to classify in any other category	33	0.07	33	98	185	52	33	0.07	0.05	0.03	0.12	0.07
Gm gr	Same as above in a group	102	0.19	162	167	162	102	103	0.20	0.14	0.13	0.32	0.18
Eee	Making a squealing sound during play	65	0.00	65	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Growl	Play growling without serious threats	81	0.00	0	0	81	0	0	0.00	0.00	0.01	0.00	0.00
Paw other	Pawing another Coyote during play	33	0.01	45	0	85	0	33	0.02	0.00	0.01	0.00	0.01
Face paw	Pawing another Coyote in the face during play	49	0.01	49	0	0	52	0	0.01	0.00	0.00	0.03	0.00
Head shake other	Grabbing neck with mouth and head shaking another during play	155	0.00	0	0	0	155	0	0.00	0.00	0.00	0.01	0.00
Bow	Lowering foreleg and elevating hind leg while wagging tail in the middle of play	43	0.01	0	0	0	43	43	0.00	0.00	0.00	0.02	0.01
LL	Leap-leap; two successive leaps during play	27	0.01	0	34	0	27	48	0.00	0.02	0.00	0.03	0.01
Walk around	Play face apparent while Coyotes are walking; play is occurring before and after these short walks; for example, this usually occurs in between wrestling bouts	125	0.01	0	0	125	0	0	0.00	0.00	0.03	0.00	0.00
Wk as gr	Same as above but while in a group	126	0.00	0	0	0	126	0	0.00	0.00	0.00	0.01	0.00
Trot around	Same as above but while trotting	80	0.03	80	284	0	174	330	0.03	0.01	0.00	0.08	0.02
Trot with coy	Trotting with Coyote with play-like body gestures	142	0.00	142	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Trot gr	Same as above but while in a group (≥2 others)	163	0.02	257	0	323	163	297	0.07	0.00	0.01	0.03	0.02
Run around	Same as above but while running	39	0.08	60	73	49	44	39	0.14	0.02	0.06	0.04	0.14
Follow/trot	Same as above but while following another Coyote; again, clearly play is occurring during these activities	54	0.05	71	92	60	54	68	0.04	0.06	0.04	0.03	0.11
A/W	During play, another Coyote approaches and withdraws from another Coyote	44	0.07	44	86	53	97	48	0.06	0.07	0.10	0.05	0.04

A/W gr	Same as above but in a group (≥2 others)	98	0.04	98	141	141	120	99	0.03	0.04	0.03	0.05	0.08
Ch	One Coyote full speed chases another Coyote around	39	0.86	39	39	51	39	39	0.95	0.62	0.61	0.79	1.34
Ch gr	Same as above but in a group (≥2 others)	55	0.53	80	80	81	58	55	0.63	0.33	0.36	0.54	0.77
Periphery ch gr	Same as above but in a full speed chase; this Coyote has no contact with the group during play bout	167	0.00	0	0	167	0	0	0.00	0.00	0.01	0.00	0.00
Circle	Two Coyotes circle each other; other play actions occur before and/or after these encounters	45	0.05	45	153	144	148	47	0.02	0.06	0.04	0.02	0.08
Circle gr	Same as above but with ≥2 other Coyotes	115	0.12	154	170	162	115	129	0.10	0.08	0.12	0.13	0.18
Hide-n-seek	One Coyote hiding and another finding it; chasing usually occurs after this	52	0.04	52	55	59	72	52	0.03	0.05	0.03	0.03	0.06
Tug o war	At least 2 Coyotes pulling simultaneously on an object (branch)	48	0.22	54	48	51	51	48	0.23	0.27	0.11	0.36	0.14
Tug o war gr	Same as above but with ≥2 other Coyotes	111	0.07	111	124	125	111	0	0.17	0.01	0.03	0.11	0.00
Wrestle (Wr)	Two Coyotes wrestling each other; fighting not observed	27	1.36	38	39	34	27	39	1.61	0.79	0.94	1.36	2.11
Wr gr	Same as above but with ≥2 other Coyotes	45	0.42	45	48	85	79	55	0.54	0.25	0.20	0.46	0.65
Wr wk	Walking while wrestling	543	0.00	0	0	0	543	0	0.00	0.00	0.00	0.01	0.00
Wr trot	Trotting while wrestling	60	0.00	0	0	60	405	0	0.00	0.00	0.01	0.01	0.00
Wr Sup	During play one Coyote submits to another and will wrestle from a SuP position; role reversal often occurs where a more dominant Coyote submits	44	0.19	44	71	51	73	44	0.27	0.06	0.15	0.12	0.35
Wr SuP gr	Same as above but with ≥2 other Coyotes	55	0.06	80	71	105	99	55	0.03	0.07	0.10	0.05	0.04
Pinning	Opposite of SuP where 1 Coyote pins another; role reversal is common here where the less dominant Coyote is the pinner	37	0.20	40	40	78	37	65	0.21	0.19	0.19	0.20	0.22
Pinning gr	Same as above but with ≥2 other Coyotes	51	0.07	98	124	100	51	94	0.08	0.05	0.03	0.04	0.13
Wr & whine	Whining while wrestling in a friendly manner	80	0.00	0	0	80	0	0	0.00	0.00	0.01	0.00	0.00
Wr & growl	Whining while growling, but in a friendly manner	71	0.01	71	71	74	80	0	0.01	0.01	0.02	0.01	0.00
Wr ch	While chasing/moving, 2 Coyotes are wrestling with each other	48	0.02	128	0	105	51	48	0.01	0.00	0.03	0.01	0.04
Wr ch gr	Same as above but with ≥2 other Coyotes	234	0.01	0	284	0	0	234	0.00	0.01	0.00	0.00	0.03
Body/hip slam	Running into another Coyote forcefully but in good spirits	39	0.00	0	179	39	0	0	0.00	0.01	0.01	0.00	0.00
Bite	Playful bite encounters	44	0.11	44	45	44	44	45	0.05	0.13	0.12	0.14	0.10
Bite gr	Same as above but with ≥2 other Coyotes	115	0.03	0	153	0	115	136	0.00	0.03	0.00	0.03	0.08
Jaw wrestle	Two Coyotes wrestling with their heads and biting neck and face	42	1.30	45	42	57	45	59	1.64	0.97	0.88	1.55	1.44
Jaw wr gr	Same as above but with ≥2 other Coyotes	94	0.14	132	100	110	115	94	0.16	0.09	0.13	0.13	0.18
Jaw wr SuP	Same as Wr SuP but one Coyote Jaw Wr from SuP position	106	0.11	106	131	119	142	118	0.11	0.13	0.09	0.14	0.10
Jaw wr SuP gr	Same as above but with ≥2 other Coyotes	119	0.01	214	131	119	257	0	0.01	0.01	0.03	0.01	0.00
Jaw wr & wk	Walking while jaw wrestling	443	0.00	443	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Sexual	Playful mounting (includes same-sex dyads) of another	42	0.03	132	43	42	42	81	0.04	0.01	0.07	0.01	0.01
N = 51	Total percentage for P:		8.67						10.16	6.81	6.50	8.88	10.95
Agnostic (Ag)	Agonistic or aggressive acts associated with conflict	33	0.09	44	34	34	34	33	0.03	0.15	0.08	0.11	0.10
Group	General aggression amongst group	37	0.01	0	50	132	37	0	0.00	0.01	0.01	0.01	0.00
SuP	Passive submission during dominance displays; not the same as in play; paws often raised at another while lying on back to keep head away from neck	33	0.44	33	34	34	39	33	0.27	0.78	0.78	0.01	0.39
Sup whine	Whining while in SuP position	34	0.01	0	239	34	0	0	0.00	0.01	0.06	0.00	0.00
SuP gr	One Coyote giving SuP to ≥2 others during agonistic situations	105	0.03	0	373	105	0	0	0.00	0.07	0.07	0.00	0.00

TABLE 1. Ethogram on eastern Coyotes *(continued)*

Parent Subcategory	Description	Age	%	Age					%				
		All 5	All 5	Cane	Caon	Late	Lupe	Trans	Cane	Caon	Late	Lupe	Trans
Whine	Coyote on alert and directing whine towards another; intimidated; ears back	331	0.00	0	0	331	0	0	0.00	0.00	0.01	0.00	0.00
Dominance (D)	Opposite of SuP where one Coyote stands over (usually tail is high) another Coyote; growling is common; fur sometimes piloerected	27	0.40	38	34	0	27	33	0.39	0.60	0.00	0.31	0.71
Shrill/screech	Similar to whine but more intense; i.e., very scared	62	0.00	0	0	74	0	62	0.00	0.00	0.01	0.00	0.01
Bark at others	Aggressively barking at others when close by	85	0.00	0	0	85	0	0	0.00	0.00	0.01	0.00	0.00
Growl	Growling at another – a low pitched rumble; agonistic pucker (vertical retraction of lips) evident; body position not noted	33	0.69	38	34	40	34	33	0.14	1.69	1.00	0.28	0.39
Growl SuP	Growling while getting pinned; this is not common because SuP is usually a very submissive act	176	0.00	0	0	331	0	176	0.00	0.00	0.01	0.00	0.01
Growl & wh	Growling and whining; clearly submissive and nervous	448	0.00	0	448	0	583	0	0.00	0.01	0.00	0.01	0.00
Growl (st)	Growling in a standing position	39	0.02	0	39	40	0	0	0.00	0.04	0.06	0.00	0.00
Growl push	Pushing another while growling	391	0.00	0	0	0	391	0	0.00	0.00	0.00	0.01	0.00
Growl sit1	Same as growl but in sit1	67	0.03	79	153	67	142	85	0.01	0.06	0.05	0.03	0.02
Growl gr sit1	Same as above but in a group	514	0.00	0	0	0	514	544	0.00	0.00	0.00	0.01	0.01
Growl sit2	Same as growl but in sit2	97	0.01	0	0	331	97	0	0.00	0.00	0.03	0.02	0.00
Growl gr sit2	Same as above but in a group	486	0.00	0	0	0	486	0	0.00	0.00	0.00	0.01	0.00
Growl wk	Growling while walking	171	0.03	507	362	171	0	483	0.01	0.11	0.01	0.00	0.03
Growl trot	Growling at another Coyote while trotting by it	363	0.02	0	518	484	0	363	0.00	0.04	0.03	0.00	0.01
Growl follow	Growling at another Coyote while following it	394	0.00	0	0	394	0	0	0.00	0.00	0.01	0.00	0.00
Growl ch	Chasing another Coyote while growling	407	0.00	0	0	407	0	0	0.00	0.00	0.01	0.00	0.00
Growl lunge	Growling and lunging at a Coyote	522	0.00	0	0	522	0	0	0.00	0.00	0.02	0.00	0.00
Def growl	Growling but body in a defensive (body and head low, ears to side) position	547	0.00	0	547	0	0	0	0.00	0.01	0.00	0.00	0.00
Def st	Standing in a defensive position (head down, ears to side, little movement); SuP like but not on back	81	0.01	0	551	134	0	81	0.00	0.01	0.01	0.00	0.01
Def st whine	Same as above with whining	479	0.00	0	479	0	0	0	0.00	0.01	0.00	0.00	0.00
Def st growl	Same as above with growling	513	0.00	0	513	0	0	0	0.00	0.02	0.00	0.00	0.00
Def sit1	Same as def st but in sit1	362	0.00	0	362	0	0	0	0.00	0.01	0.00	0.00	0.00
Def sit1 alt	Protecting its rear end from others (commonly against a fence); faces others and usually has agonistic pucker; done by lower ranking Coyotes	339	0.00	0	0	339	0	0	0.00	0.00	0.01	0.00	0.00
Def sit2	Same as def sit1 alt but in sit2 position	78	0.01	0	105	78	0	0	0.00	0.02	0.03	0.00	0.00
Def sit2 alt	Same as above but alert	331	0.00	0	513	331	0	0	0.00	0.01	0.01	0.00	0.00
Def sit2 wh	Same as above but whining	331	0.01	0	499	331	0	0	0.00	0.02	0.01	0.00	0.00
Def st alt	Same as def st but alert	185	0.00	0	518	185	0	0	0.00	0.01	0.01	0.00	0.00
Def wk	Walking with Coyote in immediate vicinity	141	0.00	0	141	0	0	0	0.00	0.01	0.00	0.00	0.00
Def wk body low	Walking with body low with Coyote in immediate vicinity	525	0.00	0	525	0	0	0	0.00	0.01	0.00	0.00	0.00
Circle def	Walking in a circle to avoid another Coyote	513	0.00	0	513	0	0	0	0.00	0.01	0.00	0.00	0.00
Circle def whine	Same as above while whining	513	0.00	0	513	0	0	0	0.00	0.01	0.00	0.00	0.00
Def lunge	Jumping at a Coyote to protect its body from being bitten	513	0.01	0	513	0	0	0	0.00	0.04	0.00	0.00	0.00
Paw other	Pawing another to try and get it to stop an Ag encounter; done by a												

	more submissive Coyote; a jaulen sound is often emitted	59	0.00	0	250	0	59	0	0.00	0.01	0.00	0.01	0.00
Push	Observed when a dominant Coyote tried to stop a submissive Coyote from getting beat up by pushing the aggressor (3rd Coyote) away	563	0.00	0	0	0	563	0	0.00	0.00	0.00	0.01	0.00
Bare teeth	Agonistic pucker where threat face is made but no growling; ears usually up in a confident Coyote and down if Coyote is nervous/submissive	263	0.01	0	380	263	0	382	0.00	0.01	0.01	0.00	0.01
Bite others	Biting at others with Ag face (threat face)	38	0.10	38	66	67	43	43	0.12	0.13	0.10	0.07	0.08
St def bite	Biting at another while standing defensively	513	0.00	0	513	0	0	0	0.00	0.01	0.00	0.00	0.00
Flee trot	Fleeing an aggressive Coyote at a trot	569	0.00	577	569	0	0	0	0.01	0.01	0.00	0.00	0.00
Flee run	Fleeing an aggressive Coyote at a run	479	0.00	0	479	0	0	0	0.00	0.01	0.00	0.00	0.00
Flee run whine	Same as above while whining	462	0.00	0	0	462	0	0	0.00	0.00	0.01	0.00	0.00
Ch	Chasing another Coyote while growling; clearly going after it	59	0.02	0	303	132	59	508	0.00	0.01	0.03	0.02	0.02
Tackle/Wr	Aggressive tackling of another Coyote; growling common	38	0.01	38	314	85	183	540	0.01	0.01	0.01	0.01	0.01
Wr gr	Same as above but in a group (≥2 others)	339	0.01	0	0	339	531	505	0.00	0.00	0.03	0.01	0.01
Gr mob	Where ≥2 Coyotes encircle and chase a Coyote; not as much body contact as a wrestle; lots of nipping and biting at the mobbee; often injurious	395	0.01	395	448	0	414	458	0.02	0.01	0.00	0.01	0.02
mobbed by others	Where a Coyote is mobbed by ≥2 others	413	0.00	0	413	0	0	0	0.00	0.02	0.00	0.00	0.00
Fight	Where 2 Coyotes go all out at each other; loud growling; biting usually to neck and/or hind-end	33	0.11	33	34	42	34	33	0.11	0.12	0.03	0.18	0.09
N = 52	Total percentage for agonistic:		2.14						1.12	4.08	2.54	1.11	1.91
Miscellaneous (MISC)	Miscellaneous categories that do not fit anywhere else												
Sit down	Going from a standing to sitting	96	0.10	114	105	96	133	394	0.12	0.13	0.10	0.10	0.07
Stand up	Going from a sitting position to standing.	42	0.06	106	119	42	102	140	0.04	0.04	0.06	0.12	0.04
St up w obj	Same as above but with object in mouth	499	0.00	0	0	0	499	0	0.00	0.00	0.00	0.01	0.00
Bite intention	Biting at another; not sure if play or agonistic	48	0.01	71	48	0	0	0	0.03	0.01	0.00	0.00	0.00
Roll	Rolling on the ground	102	0.02	102	0	298	0	0	0.03	0.00	0.05	0.00	0.00
Jump	Jumping to something like on a rock or box; occurred in different contexts than other jumps (e.g., during self play or play initiation)	39	0.05	39	47	49	58	52	0.13	0.07	0.02	0.01	0.04
Climb	Climbing on objects (e.g., fence)	33	0.01	35	40	43	0	33	0.03	0.02	0.01	0.00	0.01
Crawl	Belly on the ground; arms used to drag self around; hind legs propel self	59	0.00	59	0	0	0	0	0.01	0.00	0.00	0.00	0.00
Inguinal	Raising one hind leg to expose abdominal area when facing opposite direction of conspecific; difficult to classify; didn't seem to be greeting or agonistic towards one another	33	0.02	278	0	34	37	33	0.01	0.00	0.07	0.02	0.01
N = 9	Total percentage for MISC:		0.28						0.40	0.27	0.31	0.26	0.16

active in JGW's presence than other times of the day (Stone Zoo Keepers, personal communication).

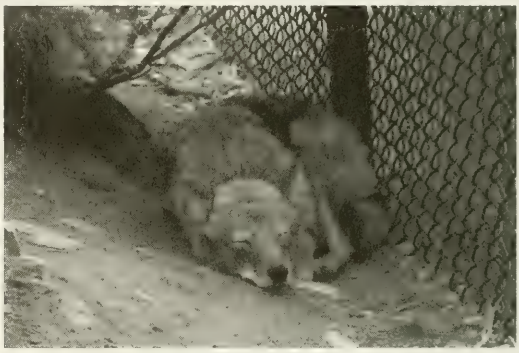
Traveling T was defined as a Coyote moving with purpose from one place to another (i.e., from point A to point B). A Coyote, when traveling, would move in a straight line and would waste little energy investigating other objects until it reached its destination. This differed from explore/investigate E/I activities, where animals were characterized by actively sniffing objects or other Coyotes, digging, and moving around in a non-direct way in order to explore their surroundings. E/I behaviour is typically not described in the literature for canids (but see Scott and Fuller 1965) yet was an important activity that our Coyotes engaged in, by far the most frequently of any parent category (Table 1; 32% of activity). The difference between explore/investigate and traveling activities would be interesting to compare between wild and captive canids. The captive Coyotes that we studied were very active but did more exploring then traveling because of the relatively small area that they lived in. Conversely, Coyotes in the wild routinely have to traverse their home ranges (Camenzind 1978; Gese et al. 1996; Way 2000) and potentially might do more traveling than exploring.

Hunting (HU) behaviour was classified when a Coyote was actively trying to catch/kill another object. Many small mammals and birds entered their enclosure, giving the Coyotes the opportunity to hunt (although we occasionally gave them live chicken chicks, we never scored the Coyotes when they were killing them). Additionally, when a Coyote was attempting to ambush a conspecific, we also classified this as hunting because its intentions were very similar to hunting prey: i.e., body very alert and focused, in a crouched position, and rushing at its intended target. Furthermore, different results occurred after an ambush; e.g., no social interactions occurred (i.e., both individuals walked away from one another), a play initiation was given once the ambusher got within close range of the Coyote, play immediately started, or fighting or agonistic behaviour ensued. Parks (1979) classified "ambushing" as a separate category in her thesis but perhaps the larger size of the exhibit in which we studied our Coyotes allowed us to detect the similarity to hunting.

Feeding was simply associated with ingesting something. Although we documented our Coyotes feeding (FE) we attempted to avoid conducting behaviours around any type of feeding time (e.g., we did not do a behavioural bout when dog chow was just placed out or when meat, rats or mice were just given to them) to avoid biasing the data.

Infantile (IN) behaviours were associated with neonatal contact as described by Parks (1979), but we also included licking/grooming one another. Because the Coyotes were in contact with other Coyotes, we believed that this was an important division for a parent category even though other behavioural complexes, such as resting, sit1 and sit 2, are included in this category. These behaviours were intermittently seen

FIGURE 1. JGW (first author) conducting a focal animal sampling bout on the Coyote to the right of him.



FIGURES 2 and 3. Coyotes sleeping in rest position.

FIGURE 4. Coyote in Sit1 Alert position.

FIGURE 5. Close-up of Coyote in Figure 4.

FIGURE 6. Coyotes in Sit1 Alert Pant position.

FIGURE 7. Coyote pup in sit2 Alert position in JGW's house.

FIGURE 8. Coyote on left in Sit1 Alert Pant position; Coyote on right in Sit2 Alert position.

FIGURE 9. Coyote in Stand Alert position.

FIGURE 10. Coyote Standing and Howling alone (lone howl).

FIGURE 11. Coyotes Standing and Group Howling.

FIGURE 12. Coyote on the right and in the back are Traveling and Trot Following the Coyote in the front.

FIGURE 13. Coyote in E/I (Explore/Investigate) Walk Sniff mode.

FIGURE 14. Coyote pack E/I Stand Sniffing.

FIGURE 15. Coyote in foreground in Hunt Ambush Crouch (Sit1) position. Coyote in background in Ambush-rush Conspecific position. This behavior can quickly turn into an Approach (Travel trot towards) when the Coyote is not in a crouched hunting mode and is moving towards another Coyote.

FIGURE 16. Coyote in Hunting mode, chasing and catching a bird.

FIGURE 17. Coyote Feeding on a rat.

FIGURE 18. Coyote Greeting Person (JGW).

FIGURE 19. Coyote in a true Greeting with JGW.

FIGURE 20. Coyote Self Playing in water.

FIGURE 21. Coyotes in Play Chase mode.

FIGURE 22. Coyotes Play Group Wrestling.

FIGURE 23. Two Coyotes Play Jaw Wrestling

FIGURE 24. Coyote trying to Play Initiate with JGW by Lying on back and Pawing.

FIGURE 25. Agonistic display. Coyote on top is in an Agonistic Dominance Display while the Coyote pinned to the ground is in Agonistic SuP (passive submission).

throughout the 18 months of observation when Coyotes would occasionally sleep on one another (especially on rainy days) or one Coyote would lick another but was not greeting it. A licking Coyote appeared to be grooming the recipient, which made it hard to place into any other category (i.e., it was doing more than simply greeting another Coyote).

Greetings (GR) were classified when non-agonistic and/or non-play interactions occurred between ≥2 Coyotes. Zimen (1982) classified many of these behaviours as neutral social contacts but we separated Zimen's descriptions of sniffing other Coyotes and left them in the explore/investigate category because the motivation was not always clear (e.g., was sniffing another Coyote a social contact or just a Coyote curious to smell another one?). Simply put, when both Coyotes licked and/or had muzzle contact with each other and/or wagged their tails in excitement to see one another, then we classified this as a greeting.

We used Bekoff's (1972a,b) definition of "play" to define our category, where play was the behaviour that was performed during social interactions in which there was a decrease in social distance between the interactants, and no evidence of social investigation or of agonistic or passive-submissive behaviours on the part of the members playing, although these actions may occur as derived acts during play (e.g., passive submission during a play bout). Bekoff (1974) also classified play as: (1) incorporating various contexts into unpredictable temporal sequences; (2) preceded by a metacommunicative signal (which we have a separate category for: i.e., play intitiation); (3) certain actions are repeated and performed in an exaggerated manner; and (4) the activity appears pleasurable to the participants: a play face (wide open jaws and eyes) is apparent.

We also included the numerous role reversals in this category where more dominant Coyotes allowed lower ranked Coyotes to pin them to the ground; this was never documented during agonistic displays. Bekoff (1974) includes a description of this occurring amongst western Coyotes but does not delineate it as part of classifying play. Additionally, we separated play initiation from play because the attempter was not always successful in initiating play during an attempt; i.e., they appeared to be two separate categories. We observed many play initiation-like (e.g., approach/withdraw and general movements) behaviours occurring during play, but because they happened during play we kept them in this category; i.e., play was already initiated. Self play (PS) was similar to play but when a Coyote was by itself. Altogether, play-like sequences accounted for ca. 10% of all observations (Table 1).

Agonistic (AG) behaviours were classified as aggressive acts associated with conflict where there were clear acts of dominance and submission or where growling or fighting was observed (Fox 1969; Scott and Fuller 1965; Zimen 1982). About 2% of all activities were aggressive, especially towards the end of the study when Coyotes were separated. Finally, a miscellaneous (MISC) category was one where we could not classify the behaviour pattern into any of the other parent systems; these were very infrequent (Table 1).

Despite the large number of behavioural patterns described herein, there are some important omissions in our ethogram. First, because the Coyotes were all siblings and were young adults (18 months) when the study ended, we did not notice any sexual/reproductive behaviours (although it was witnessed during their second winter: J. Way, unpublished data). Future ethograms should add this behaviour as a separate (parent) category much as Scott and Fuller (1965), Zimen (1982), and Goodmann and Klinghammer (1990) did with their respective ethograms. Second, because the Coyotes were taken from the wild at 25 days of age, we missed many basic neonatal behaviours, such as crawling and nursing (Scott and Fuller 1965; Scott 1967; Parks 1979). Third, because the Coyotes were all siblings and of the same age, we could not document any adult-pup interactions such as epimeletic behaviours, i.e., the giving of care (Scott and Fuller 1965). However, many times we did document et-epimeletic behaviours where the Coyotes were soliciting or calling for care where they would whine, wag their tails for a greeting (with JGW and/or another Coyote), and lick one another. Fourth, the full range of hunting behaviours (e.g., killing/biting prey) was not documented mainly because of the rarity of observing a kill – especially during the 15 sec intervals when we recorded data. Finally, there were some different behavioural actions that we could have added but simply did not because of the sheer volume of our ethogram. For example, under infantile behaviour we have sit1 and sit2 although we do not note if their eyes are open or closed. Because both examples were rarely observed, this was a minor detail in the overall scheme of Table 1, but it does illustrate the arbitrarily defined nature of any ethogram (Schleidt et al. 1984), no matter how simple (i.e., the parent categories) or complex (i.e., the behavioural actions) it is. Also, we thought that sit1 and sit2 were logical separations due to the noticeably different body positions; however, we theoretically could have had many more sitting positions based on a combination of head, body, and leg positions.

Although we attempted to be consistent with our behavioural classifications, there was no doubt that drift occurred in our categorizations (MacDonald et al. 2001). For example, many of the behaviours occurred well before first noted on Table 1. Although usually very similar to other categories (for example E/I wk sn and E/I st sn versus E/I step sn; Table 1) a new category randomly created during the study certainly introduces a bias to the finally tally of percentages in Table 1. However, the goal of this study was to produce an end product (i.e., the ethogram) even at the expense of being consistent throughout – i.e., there was no available model of a typical ethogram on wild canids. Also, a number of simple, but newly recorded, behaviours occurred after the study concluded. For example, E/I step sniff became much more frequent no doubt because of the new category described not because a Coyote just started doing that action pattern. Also, stand step alert and stand alert move head were described soon after this ethogram was finalized (J. Way, unpublished data). Although these were commonly recorded after the Coyotes were separated they

were not described herein. That being said, we believe that the ethogram is largely complete and that these slight nuances are offset by our rationale of producing the ethogram when all five Coyotes were housed together (i.e., before they were permanently separated) and the fact that the main categories would stay virtually identical even with these changes.

The categories that we created are intended for ease of use in the field where a researcher can simply note the major behavioural system observed and the behavioural pattern associated with it. One advantage of this ethogram is that it is in discrete units (i.e., the behavioural patterns). However, data could always be lumped together (i.e., into general behavioural systems or ≥2 behavioural patterns could potentially be combined into one action) if the data/list are unmanageably large (e.g., when studying wild Coyotes). The disadvantage of merging behaviours into more broad groupings is that parent categories or lumped behavioural patterns can never be split back into more distinct behavioural patterns if not done at the outset; as Bekoff (1972b) indicated, this would cause data to be irreversibly lost.

The previous studies that have described canid behaviours were quite variable (Scott and Fuller 1965; Silver and Silver 1969; Bekoff 1972a; Parks 1979; Zimen 1982) so we basically combined data/categories from all of these studies and made modifications or additions as needed in order to try to create an accurate yet practical guide for researchers studying canids in the field. Future research should try to generate similar ethograms for other species and should continue to modify and/or expand our list if new behavioural actions are found with Coyotes. Analyzing ethograms of closely related species may be one technique to effectively discriminate between them (e.g., Western Coyotes, Eastern Coyotes and Wolves – Silver and Silver 1969; Bekoff 1978).

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Editor's Note

A description of these Coyotes "in layman's language" is now available.

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First Observations of an Eastern Screech-Owl, *Megascops asio*, Population in an Apple-Producing Region of Southern Quebec

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Baseline information was collected on a local Eastern Screech-Owl population found in the apple-producing region of Saint-Hilaire and Rougemont, Quebec, as part of a larger study on pesticide exposure conducted between 2000 and 2003. Screech-Owls visited or occupied 41 of 89 nest boxes installed in 12 orchards and 2 control locations. The mean height of occupied nest boxes was 3.83 m (2.00 – 5.80 m). Squirrels, *Sciurus* and *Tamiasciurius* sp., and chipmunks, *Tamias striatus*, Northern Flickers, *Colaptes auratus*, and wasps were the owls' primary competitors for the boxes. Intact Screech-Owl pellets retrieved from nest boxes (n = 82) had a mean length and width of 3.57 and 1.44 cm, respectively, and weighed a mean of 1.77 g. Screech-Owls in the study area consumed a variety of small mammal, avian, insect and aquatic prey. Of these, Meadow Voles, *Microtus pennsylvanicus*, were the predominant prey item identified in pellets, and Mourning Doves, *Zenaida macroura*, were the primary avian prey found in nest boxes. In Canada, the owl's trend status remains largely unknown. The species is currently listed as "Not at Risk", based on an assessment conducted for COSEWIC in 1986. Given that a limited amount of information exists on the natural history and ecology of the species in Quebec, we also generated a map of the owl's distribution in the province, using data from ornithological databases and rehabilitation facilities. Potential risks to the species within the province, particularly pesticide exposure and habitat loss, are briefly addressed and follow-up studies are discussed.

Key Words: Eastern Screech-Owl, *Megascops asio*, natural history, ecology, apple orchard, Quebec, range, distribution, census, pellet analysis, prey inventory, nest box, wing chord, population management, pesticide exposure, habitat loss, development, conservation.

The Eastern Screech-Owl, *Megascops asio*, has been extensively studied in the United States (i.e., VanCamp and Henny 1975; Gehlbach 1994a). However, it has received considerably less attention north of the border, where it occupies a much smaller area. Within Quebec, the Screech-Owl's range is vaguely delineated and general knowledge about the species is limited. As part of a study assessing the exposure of the Screech-Owl to pesticides currently and previously used in apple orchards of southern Quebec (see Richards et al. 2004, 2005), we collected baseline information on the species. Here, we present observations on a population of Eastern Screech-Owls (Figures 1, 2, 3 that resides in one of the primary apple-producing regions of Quebec.

Methods

Mapping the range of the Eastern Screech-Owl in Quebec

We obtained case files from the Clinique des oiseaux de proie (COP), based in Saint-Hyacinthe, and the Center for the Rehabilitation of Injured Birds of the Montérégie (CRIB), based in Otterburn Park, which administer care to the majority of injured or orphaned owls in the province. The locations from which adult and juvenile Screech-Owls were admitted were tabulated and mapped. These data harbour certain biases and so were used only to illustrate the overall, rather than density, distribution of the species within Quebec. For example, the number of owls admitted from an area is positively correlated with its proximity to the nearest rehabilitation facility (Richards et al., unpublished data). Visibility and predisposition to capture can artificially inflate admission numbers; in this case facilities tend to receive an influx of orphaned Screech-Owl babies and fledglings in the late spring and summer, largely from suburban settings, where they are highly conspicuous (Richards et al., unpublished data). Thus, each admission location was given one data point, and multiple admissions from any given area were not considered an indication of a large Screech-Owl population or that it was especially suitable for the species.

We also obtained Screech-Owl locations from the Études des populations d'oiseaux du Québec (ÉPOQ) database, which is managed and continually updated by members of ornithological clubs and societies belonging to the Association québécoise des groupes d'ornithologues (AGQO). Finally, we contacted personnel from the Ontario Breeding Bird Atlas project (OBBA) and from the New Brunswick division of Bird Studies Canada to ensure that our map represented the species' range at the eastern and western borders of Quebec as precisely as possible.

Site selection and censusing

All fieldwork was carried out in orchards of Rougemont and Saint-Hilaire (45°28"73°W to 45°32"73°N), two adjacent apple-producing regions of southern Quebec. The study region was first surveyed in the summer of 2000 for areas containing habitat requirements for Screech-Owls; i.e., mature and mixed forest with old cavity-ridden trees and conifers for shelter, as well as running water. Potential orchards and control sites were then censused between November and March 2000 and 2002. By November, most first-year individuals should have dispersed from their natal habitat and established a territory. Thus, owls that respond are likely to be established, rather than transient, individuals. This provides a "true sense" of occupancy. We have found, based on our experience censusing Screech-Owls in southern Quebec, that this timeframe also corresponds to the period when individuals are reasonably responsive to broadcast calls.

We walked or snowshoed between the edge of the orchard and the adjacent forest, broadcasting a combination of "bounce" (territorial) and "whinny" (defensive) calls into the forest from a small, hand-held tape player. Between 3 and 7 minutes of silence followed, and then the calls were repeated. If a response was not obtained, we then proceeded around the perimeter and repeated the process roughly 10 minutes later. When a response was obtained, the presence of an individual was visually confirmed with a headlamp or flashlight and its colour phase was noted. Two individuals observed in the immediate vicinity of one another (i.e., perched in the same tree) were considered a pair. We also noted responses from Barred Owls, *Strix varia*, or Great Horned Owls, *Bubo virginianus*. The presence of these potential predators in an area may cause Screech-Owls to suppress vocalizations (Fuller and Mosher 1981), restrict the size of their territory, or deter them from establishing themselves altogether (Gehlbach 1994a).

The locations were then re-censused every winter to verify whether or not they were still occupied. The 12 orchard and 2 control sites where Screech-Owls were observed in the winter were censused again in June and July of 2001 and 2002. Given that Screech-Owls are not always particularly cooperative even under optimal conditions, locations were repeatedly censused (at least twice) if a response was not obtained during the first censusing effort. We did not census when wind speed exceeded 15 km/h, or during rain or snow, to ensure that censusing was carried out under the best possible conditions.

Nest box installation and inspection

Between 2000 and 2002, 89 nest boxes were installed in the forests where Screech-Owls responded during our initial censusing efforts. All orchards were assigned a letter code to maintain orchard-owner confidentiality. Boxes were constructed of pine, *Pinus* sp., or Eastern Hemlock, *Tsuga canadensis*, with dimensions for American Kestrel, *Falco sparverius*, as per Henderson (1992). Material does not appear to influence nest box selection by Screech-Owls (Gehlbach 1994b). One caveat is that boxes made of hemlock must be stored under conditions of relatively uniform heat or they will crack and warp. Pine boxes are heavier and more challenging to transport but much more resistant to temperature fluctuations, both inside during storage and in the field.

Between 1.0 and 2.0 inches of dust-free wood chips were placed in the bottom of each box. The distances from the base of the box to the ground and from the box to the nearest orchard edge were recorded. Nest box covers were secured on each side with spring-loaded latches to facilitate inspections while minimizing entry by mammalian predators, particularly Raccoons, *Procyon lotor*. Though most locations were fairly remote, boxes installed in areas regularly accessed by the public were painted with a brown, non-toxic paint, and placed a greater distance from the ground to reduce visibility and the possibility of disturbance or vandalism (as described in Gehlbach 1994b).

Boxes were initially inspected for pellets and prey remains 3 to 4 times per year: in the spring, in mid to late summer, in the late autumn and in the early winter, depending on ease of accessibility to each site especially during periods of heavy snowfall. However, we soon stopped inspecting in the spring and summer because of the disturbance posed to other species occupying the boxes; unfortunately, we unwittingly caused nuthatch, *Sitta* sp., and European Starling, *Sturnus vulgaris*, parents to abandon their nests. From an ethical and logistical perspective, the late autumn and early winter were deemed the best times to inspect nest boxes. Thus, between 2003 and 2004, boxes were inspected once or twice per year in the late autumn and/or early winter. When prey items were found, boxes were emptied and replenished with wood chips to prevent duplication of results on subsequent visits. Recovered wood chips were carefully sifted for pellets or prey items.

Pellets, prey remains and prey inventory

Pellets were air-dried prior to dissection for prey identification. Length, width and weight of intact pellets were recorded. Small mammal species were identified by lower mandible (Cahn and Kemp 1930; Rac-

zynski and Ruprecht 1974), using a reference collection of known skulls and mandibles. Vole species were further distinguished as *Clethrionomys* or *Microtus* sp. using Maisonneuve et al. (1997). Avian prey were identified to species from feather remains with the help of two local wildlife rehabilitators, and referring to Elbroch and Marks (2001). An inventory was then drawn up for each of the locations where prey items were found.

Screech-Owl captures

Screech-Owls were initially captured between June and August of 2001 and 2002 as part of an unsuccessful attempt to radio-track them and evaluate their use of orchards in relation to pesticide applications. We set up a mist net and a bal-chatri trap baited with a white mouse within orchards but near adjacent forest (as per permits no. 2001-05-07-103-16-SF and 2002-06-10-120-16-SF). We then broadcast defensive and territorial calls into the forest to attract owls. Capture attempts were initiated just prior to or soon after dusk.

All captured adults and young were processed on-site. First, they were placed headfirst into a clean Pringles® chips canister and weighed with a 300 g spring-loaded Pesola scale. After the owl was removed from the canister, the keel region was gently palpated and a keel index was assigned on a scale of 0 to 5, with 1 being "emaciated", 3 being of "medium" weight, and 5 being "obese". The wing chord was also measured. Owls were aged as adults based on the presence of blood feathers and on other evidence of moulting. It was not possible to sex individuals. All owls were banded and released.

Results

Range map

One hundred and sixty-nine locations were plotted: 20 from the COP (records spanning 1998 to 2001), 17 from the CRIB (records spanning 1988 to 2003), 7 from the OBBA (2001 to 2004 data) and 125 from the EPOQ database (1940 to 2004). According to the personnel at the New Brunswick division of Bird Studies Canada, the species is incidental at best in the Maritime provinces, and they were unable to provide us with definitive sightings.

Censusing

Between the winters of 2000 and 2002, we censused 27 orchards and 3 potential control sites. We received a response from Screech-Owls in 12 orchards and 2 control sites, one a wooded area near a trailer campground and the other in the research sector of the Mont-Saint-Hilaire Biosphere Reserve. Four pairs and 7 individuals were observed during censusing and all were grey-phased.

Great Horned Owls or Barred Owls were heard or seen in the vicinity of 6 of the 14 locations occupied by Screech-Owls and 6 of the 16 remaining locations. It is likely that some or all of the locations where we did not obtain a response are frequented by one or both species; the habitat observed is suitable and they are all either quite close to the Mont-Saint-Hilaire Biosphere Reserve or to Mont Rougemont, both of which have Great Horned Owl and Barred Owl populations (C. Cormier, personal communication 2003).

FIGURE 1. Distribution of the Eastern Screech-Owl (*Megascops asio*) in Quebec.

Nest box occupation

A nest box was considered occupied if pellets, prey remains or an owl were observed in it during inspections (Table 1). To determine whether height of nest box or distance from box to nearest habitat/forest edge influenced its selection or use, we first considered the height and distance of those boxes occupied *at least once* by a Screech-Owl. Then, we further refined our analysis to nest boxes for which we had evidence of multiple uses, defined as three visits or more (Table 2): either evidence of occupancy on at least three separate nest box inspections or discovery of at least three pellets or prey remains, given that Screech-Owls generally regurgitate one pellet per resting period.

We measured the distance from the tree on which nest boxes were installed to the nearest "true' edge", an important distinction as a network of paths criss-crossed most of the forests in which boxes were installed. True edge was defined as an expanse of open area immediately adjacent to, rather than contained within, the forest itself, such as a field or an orchard. Box distance ranged from 0 to 68.0 m from edge.

TABLE 1. General nest box occupancy of Eastern Screech-Owls, by location, in Saint-Hilaire and Rougemont, Quebec areas (2000 – 2004).

Location	Number of boxes installed	Percent occupation
Campground	9	89
Biosphere Reserve	6	100
A/A1	7	14
B	10	30
K	8	25
C	5	20
D/F	10	100
G	7	14
I	11	0
M	7	29
N/N1	9	78
Total	89	

A variety of other species occupied the nest boxes (see Table 3). To determine the overall frequency of nest box use, we evaluated the total number of times boxes were occupied by Screech-Owls at each site over the course of the study relative to other species. Table 4 shows occupation by the most commonly observed species in relation to that by Screech-Owls.

Pellets and prey remains

Nest boxes were installed at the 12 orchards and 2 control locations where Screech-Owls responded to censusing. However, in some of these locations, there was little or no evidence (i.e., pellets or prey remains) that Screech-Owls ever occupied these boxes. Only one pellet was found at Orchards A/A1, C and M, so these were excluded from the prey inventory analysis (Table 5). Intact pellets were retrieved from 8 of the orchards, including C and M, which *were* included in the analysis of pellet dimensions.

TABLE 2. Mean height from ground of nest boxes ($n = 41$) occupied by Eastern Screech-Owls in Saint-Hilaire and Rougemont areas, Quebec (2000 – 2004).

	Height from ground (m)	Range
Unoccupied boxes ($n = 48$)	4.22	2.40 – 6.82
Occupied boxes ($n = 41$)	3.83	2.00 – 5.80
"High-use" nest boxes ($n = 33$)	3.67	2.00 – 4.72

Screech-Owl captures

Despite repeated censusing, a response was never obtained in Orchards G or M. These locations were therefore excluded from capture attempts. We did obtain a response in Orchard C, but the owl never deigned to approach our traps.

Nine individuals were captured in the summers of 2001 and 2002. On occasion, Screech-Owls began to respond to broadcast calls while some daylight remained. However, owls were always captured under cover of darkness, between 21:15 to 03:10. Though we were not always able to capture all the individuals observed, we did record their presence (see Table 6). Of the nine captured individuals and six observed, but not captured, only one was red-phased; the rest were grey.

Discussion

Eastern Screech-Owl range in Quebec

The Eastern Screech-Owl's northernmost North American range coincides with the southern tip of Quebec (Gauthier and Aubry 1996). To the west of Quebec, the species is commonly reported along the southern edge of Ontario in the Carolinian zone along Lake Erie and Ontario. More local and uncommon populations extend up another 100 to 200 kilometres north. In eastern Ontario, there appears to have been

TABLE 3. Nest box occupancy by other species.

Mammal occupant	Avian occupants	Other
Eastern chipmunk	Great Crested Flycatcher	*Hymenoptera:*
(*Tamius striatus*)	(*Myiarchus crinitus*)	ants, bees*, wasps
Southern Flying squirrel	Downy Woodpecker	*Eupplexoptera:*
(*Glaucomys volans*)	(*Picoides pubescens*)	Earwigs
Grey squirrel	European Starling	Unknown snake**
(*Sciurus carolinensis*)	(*Sturnus vulgaris*)	
Jumping Mouse	Hairy Woodpecker	*Arachnid:*
Zapodidae	(*Picoides villosus*)	Spiders
Red squirrel	Northern Flicker	*Coleoptera:*
(*Tamiasciurus hudsonicus*)	(*Colaptes auratus*)	Unknown beetles
	White-breasted Nuthatch	
	(*Sitta carolinensis*)	

*could also have been cached prey item

**snakeskin found, could also have been part of nesting material

an overall expansion of the range in the last 20 years (M. Gahbauer, personal communication, 2004). To the east of Quebec, the range may extend into the extreme southwestern part of New Brunswick (Gauthier and Aubry 1996); however, there are no confirmed breeding records for the species there. If Screech-Owls do in fact breed in New Brunswick, it is likely to be in very low numbers (B. Whittam, personal communication, 2004). Screech-Owls have also been observed in Nova Scotia and in Prince Edward Island, but their presence there is thought to be incidental (*ibid*). Elsewhere in Canada, the range is defined as extending from southwestern Saskatchewan to southern Manitoba (Panak 1988*). All of the above suggests that an important proportion of the species' range in Canada occurs in Quebec and in Ontario.

Censusing

For our purpose, which was to confirm the presence of resident Screech-Owls at a given location, we found the optimum census period to be between November and February. There are several logistical advantages to censusing towards the beginning of this period. During the early winter months, pairs jointly defend their territory and are very responsive to broadcast calls. As a result, there is a greater likelihood of obtaining a response from both the male and the female, which eliminates the need for speculation as to whether or not a location is occupied by a pair. Later on, heavy snowfall can lengthen the time required to census each location considerably, and render some virtually inaccessible.

Censusing can have adverse effects. In late February and early March, females select a suitable nesting location, then remain in or near their cavity. Broadcast calls may elicit a response from territorial males, but

FIGURE 2: A grey-phase Screech-Owl discovered during a mid-winter census at the Réserve écologique Marcel-Raymond, Henryville, Quebec, near the Richelieu River. Photographed by Léopold Gaudreau, Assistant Deputy Minister, Sustainable Development Branch, Ministère du Développement durable, de l'Environnement et des Parcs, 9 December 2006.

TABLE 4. Frequency of nest box occupation in orchards and control sites of Saint-Hilaire and Rougemont areas, Quebec (2000 – 2004)

Location	Number of boxes inspected**	ESOW	CH/SQ	NOFL	WASP	OTHER	NO
Biosphere Reserve	38	26	2	1	0	0	9
Campground	116	48	26	3	5	5	29
A/A1*	60	8	4	5	1	7	35
B/K*	173	16	39	9	7	9	93
C	47	4	10	6	1	1	25
D/F*	103	20	33	2	3	4	41
G	51	5	13	2	1	5	25
I	67	2	29	0	1	9	26
M	39	4	22	0	2	0	11
N/N1*	59	13	24	1	3	7	11
Total	753	146	202	29	24	47	305

*Orchards are side by side or adjacent
**Indicates number of boxes inspected at location over duration of the study
ESOW: number of boxes occupied by Screech-Owl
CH/SQ: number of boxes occupied by chipmunk or squirrel
NOFL: number of boxes occupied by a Northern Flicker
OTHER: number of boxes occupied by other inhabitants (see Appendix 1)
NO: number of unoccupied boxes

TABLE 5. Eastern Screech-Owl prey inventory based on pellets and prey remains found in nest boxes at 6 orchards and 2 control sites in Saint-Hilaire and Rougemont areas, Quebec (2001 – 2004)

Scientific name	Common name	D\F[a]	B\K	N\N1	Biosphere Reserve	Campground
Blarina brevicauda	Short-tailed Shrew		2	3	3	5
Microtus pennsylvanicus	Meadow Vole	8	5	31	53	19
Peromyscus sp.[b]				1		5
Sorex sp.[c]		5			1	
Zapodidae[d]		1		3	13	1
Aegolius acadicus	Northern Saw-whet Owl				1	
Bombycilla cedrorum	Cedar Waxwing					2
Cardinalis cardinalis	Northern Cardinal				1	
Carduellis tristis	American Goldfinch					1
Colaptes auratus	Northern Flicker					
Columba livia	Rock Dove					3
Cyanocitta cristata	Blue Jay	1			1	1
Junco hyemalis	Dark-eyed Junco					1
Molothrus ater	Brown-headed Cowbird	1				
Poecile atricapillus	Black-capped Chickadee	1				
Picoides villosus	Hairy Woodpecker		1			1
Quiscalus quiscula	Common Grackle					1
Sayornis phoebe	Eastern Phoebe	1				
Sturnus vulgaris	European Starling				1	
Toxostoma rufum	Brown Thrasher	1				
Turdus migratorius	American Robin		1			1
Zenaida macroura	Mourning Dove	4	1		1	8
Sittae	unidentified nuthatch				1	
Turdidae	unidentified thrush	2		1	1	
Tyrannidae	unidentified flycatcher		1	5		12
Unidentified bird[e]						
Miscellaneous artifacts and prey						
Apis mellifera	Honey Bee	2		2		2
Rana clamitans	Green Frog	1				3
Unidentified membrane[f]		2			1	2
Corn, seeds		1		1		1
Eggshell fragments					1	2

[a] data spans 2001-2003 only
[b] White-footed or Deer Mouse
[c] Masked or Smoky Shrew
[d] Meadow or Woodland Jumping Mouse
[e] down remains unidentifiable
[f] may be the remains of a frog

TABLE 6. Eastern Screech-Owls ($n = 9$) captured and banded in one control and six orchard locations of Saint-Hilaire and Rougemont areas Quebec (2001-2002), by month of capture. See methods for keel index categories.

Location	Capture date	Captured individual	Weight (g)	Keel index (0-5)	Wing chord (mm)
Orchard I	22 July 2001	1 adult[a]	183	2.5 to 3.0	170
Campground Control	13 July 2002	1 adult	78.0	3	177
		3 juvenile	78.0, 94.0, 96.0	2, 3, 3	182,184,194
Orchard K[b]	31 July 2002	1 adult	160	3	176
Orchard A/A1[c,d]	9 August 2002	1 adult	159	4	176
		1 juvenile	155	3	185
Orchard D/F[c,e]	29 August 2002	1 juvenile	171	4	178

[a] red-phased individual
[b] 1 adult and 1 juvenile observed but not captured at B in June 2002
[c] orchards are adjacent to one another and considered to comprise one territory
[d] 1 other juvenile observed but not captured
[e] 1 adult and 2 juveniles observed in June 2001 but not captured

FIGURE 3. An Eastern Screech-Owl peers sleepily from a cavity at Parc Summit on the Island of Montreal. As development within the province increases, so too does the importance of the parks and protected areas within the species range. Photo by Jean-Sébastien Guénette, 17 April 2005.

given the necessity of devoting their energy to provisioning their mate and themselves, and to defending their territory against real rather than perceived intruders, censusing at this time can impose an unnecessary and potentially harmful stress. Predators of the Screech-Owl can also be attracted to the broadcast calls, and to respondents, especially if illuminated by a flashlight or headlamp. We are aware of one instance, for example, where a Long-eared Owl, *Asio otus*, was drawn to a Screech-Owl during censusing and was illuminated in the process of closing in on it. Since this study, a "minimal-disturbance" censusing protocol has been developed for the Screech-Owl and for other owl species (see Balej 2006).

Nest Box inspections

Nest boxes ($n = 89$) were installed in the vicinity of where Screech-Owls responded during censusing. Ordinarily, an owl's presence in an area would go largely undetected because they are very inconspicuous and occupy natural cavities. As the study progressed, our primary concern became to place the nest boxes at a height that would reduce the possibility of drawing untoward human attention to them. Overall nest box occupation at each location varied from 0% to 100%. Forty-one boxes were occupied at least once by an owl, and these boxes were a mean of 3.8 m (2.0 to 5.8 m) from the ground (Table 2). Gehlbach (1994b) found owls nesting, on average, 3.7 m from the ground in natural cavities ($n = 23$).

A number of species may compete with Screech-Owls for nest boxes. The four most frequent occupants were squirrels, *Sciurus* and *Tamiasciurius* sp., and chipmunks, *Tamias striatus*, Northern Flickers, *Colaptes auratus*, and Hymenoptera, especially wasps. During pre-snowfall inspections in October and November, we frequently removed nesting material left by other species, and during inspections the following spring found Screech-Owl pellets and prey remains. Occasionally, Screech-Owls deposed chipmunks and squirrels, judging from pellets or prey remnants deposited over nesting material. Northern Flickers have been reported to destroy Screech-Owl eggs (Penak 1986*). However, the Screech-Owls in our region infrequently (22 of the 146 recorded times) occupied nest boxes in the summer and early autumn months, when Flickers occupied them. Late autumn inspections enabled us to remove nesting material left by other species (or by Screech-Owls during the winter). We also could replenish the boxes with wood chips during these visits without having to disturb any of the species that had previously occupied the boxes and make any necessary repairs.

Pellets

The intact pellets retrieved from nest boxes ($n = 82$) ranged widely in length from 1.0 to 8.5 cm and from 0.8 to 3.2 cm in width, with a mean weight of 1.77 g. Elbroch and Marks (2001) recovered Screech-Owl pellets ($n = 18$) from nearby Vermont and New Hampshire which ranged from 1.6 to 3.8 cm length and 0.9 to 1.4 cm width. Fifty-six of our pellets exceeded the upper length and width reported by Elbroch and Marks. Most of the intact pellets we measured were retrieved from nest boxes, where they were protected from the elements and from breaking. This, and our larger sample size, may explain the discrepancy in our upper reported length.

Prey Consumption

Meadow voles were the predominant intact prey item found in our nest boxes. Screech-Owls are also highly insectivorous (Ritchison and Cavanagh 1992), and although we repeatedly found evidence of insect consumption, we were unable to fully assess or quantify it. Only insects with hard parts, such as beetles, *Coleoptera*, can be distinguished in pellets. For the most part, we found only a dust of legs and carapaces intermingled with the wood chips and with other artifacts. Mourning Doves were the avian prey most frequently found in nest boxes, but few avian prey remains were found. Screech-Owls may simply prefer to pluck feathers on a perch or in a deeper tree cavity rather than in a nest box which feathers could potentially fill quite quickly. Hence, our prey inventory underestimates avian and insect consumption. As well, several cached frogs and shrews, and a decapitated vole, were also found in nest boxes at the Campground control site. On a number of occasions, remnants of crayfish and fish scales were recovered from this site, as well as pieces of a greenish membrane, which may have been a remnant from the frogs. The greatest diversity in prey items seems to have been consumed at the Biosphere Reserve.

Conclusion

The Screech-Owl is found in suburban, rural and agricultural habitats. It is considered to be one of the most ubiquitous owls in North America (Gehlbach 1995). There is, however, very little information available about the species' natural history and ecology, or about its density and overall distribution in Canada, where its status was last evaluated for the Committee on the Status of Endangered Wildlife in Canada over 20 years ago (by Penak 1986*). Paradoxically, the species is currently designated as "Not at Risk", even though there are no current data on its population trend status (http://www.cws-scf.ec.gc.ca/mgbc/trends/index.cfm?lang=e&go=info.bird&speciesid=3730).

An important part of the species' range in Canada occurs in southern Quebec, where it coincides with an agricultural belt and with the province's major apple-producing region. Screech-Owls are known to favour orchard habitats (Gauthier and Aubry 1996) where pesticides are intensively applied. Our study evaluating the exposure of Screech-Owls to pesticides currently and previously used in one of the largest apple-producing regions of southern Quebec provided an opportunity to collect information on the species' regional diet, record physiological parameters, evaluate occupation response to nest boxes and gain a sense of the density and distribution of the local population. As far as we know this is the first time that these types of data have been collected on the Screech-Owls of the area.

More baseline information of this type must be gathered for future monitoring and population management efforts throughout the owl's Canadian range. Changes in development and land use patterns must also be examined. While we found that exposure to DDE and organophosphorus pesticides warranted further investigation (see Richards et al. 2004, 2005), we also observed a marked increase in clearing and development of forested lands and orchards over the course of the study. We believe that loss of habitat and overall decrease in habitat quality currently pose a far greater threat to the local population than exposure to pesticides.

Our colleagues at the Quebec environment ministry (Ministère du Développement durable, de l'Environnement et des Parcs) have been conducting autumn and winter censuses in ecological reserves within the known range of the species since 2005. This is part of an ongoing study initiated to evaluate the relative risks that pesticide exposure and habitat loss/deterioration pose to Screech-Owls in southern Quebec (if interested in collaborating on this study, please contact N. Richards).

Even if the North American Screech-Owl population may not be at risk as a whole, we are concerned that habitat loss and modification may be adversely affecting regional populations. At the very least, a re-examination of the Screech-Owl's distribution and population status throughout its Canadian range, especially in Quebec and Ontario, is long overdue. If this adaptable and opportunistic species is being adversely affected, how does this bode for the more vulnerable species which occupy the same habitats?

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Effects of Timber Harvesting and Plantation Development on Cavity-nesting Birds in New Brunswick

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We studied the abundance of cavity-nesting birds in forestry-related habitats in a region of Acadian forest in New Brunswick. We examined five reference stands of natural forest, a chronosequence of conifer plantations up to 19 years old (the oldest in the study area), two selectively harvested stands, and a 30-year-old naturally regenerated clear-cut. The species richness and abundance of cavity-nesting birds were higher in reference forest (average 10.0 species per stand; 5.3 territories per 10 ha) than in plantations (2.3/stand; 1.0/10 ha), selectively harvested stands (7.0/stand; 3.8/10 ha), or the naturally regenerated clear-cut (5.0/stand; 2.5/10 ha). A cluster analysis segregated the "community" of cavity-nesting birds of natural forest from those of other treatments. Of the various harvested stands and plantations, five with a relatively large number of residual snags clustered similarly in the cluster analysis, while those with no or very few snags also clustered together. We used arrays of nest boxes (12 per stand) to examine whether the availability of cavities was limiting the use of habitats otherwise suitable for foraging by cavity-dependent species. Nest-box use for nesting and roosting was much higher in the seven plantations examined (average 4.0/10 ha for nesting and 2.9/10 ha for roosting) than in three reference stands (each 0.3/10 ha), suggesting that the plantations were deficient in this critical-habitat element. Our results suggest that certain mitigations, such as leaving residual snags and living cavity-trees, would help maintain populations of some cavity-dependent birds in clear-cuts and plantations. However, some cavity-dependent species might not be accommodated by these mitigations and are potentially at risk in intensively managed areas, unless landscape-scale management plans ensure the survival of sufficient areas of older mixed-wood forest.

Key Words: Acadian forest, cavity-nesting birds, conifer plantations, critical habitat, forestry, management recommendations, nest boxes, New Brunswick.

The effects of forestry on biodiversity range over a wide continuum, depending largely on the intensity of harvesting and subsequent management (Hunter 1990; Freedman et al. 1994; Angelstam and Milkusinski 1994; Freedman 1995; Hagan et al. 1997; Niemi et al. 1998; Imbeau et al. 2001; McRae et al. 2001; Kimmins 2003). For instance, clear-cutting followed by intensive management to develop an even-aged monocultural plantation has relatively extreme effects, while the effects associated with selective-harvesting and natural regeneration are much smaller. In boreal Europe, for example, natural pine (*Pinus sylvestris*) forest has been converted extensively into commercially preferred, short-rotation conifer plantations (Esseen et al. 1997), resulting in large declines of birds dependent on older natural forest (Virkkala 1991). Similar changes are occurring in temperate- and boreal-forest regions of Canada, where older mixed-species forest is being converted extensively into conifer plantations (Niemi et al. 1998; Imbeau et al. 2001; McRae et al. 2001).

Cavity-dependent birds in temperate and boreal forest are generally most abundant and species-rich in older, uneven-aged, mixed-species stands (Hunter 1990; Schreiber and Decalesta 1992; Newton 1994; Freedman et al. 1996; Hobson and Schieck 1999; Schieck and Hobson 2000). Intensive forestry practices generally decrease the richness and abundance of cavity-dependent birds by causing the following habitat changes to occur (Niemi et al. 1998; Hobson and Bayne 2000; Flemming and Freedman 1998; Imbeau et al. 2001; Kirk and Machtans 2004; McRae et al. 2001):

- the conversion of natural forest having complex biological and physical structure (i.e., multi-species stand composition and intricate spectra of age and size) into silvicultural plantations dominated by a monospecific cohort of similar-sized and -aged trees
- the reduction in quantity of cavity trees, dead snags, and coarse-woody debris by intensive management practices (in Canada and elsewhere snag felling may even be required under health and safety regulations; e.g., Naylor et al. 1999)
- the truncation of stand age-at-maturity by short-rotation management (typically 40-60 years), which precludes the regeneration of large cavity-trees and coarse-woody debris

Moreover, at the level of landscape, forestry typically decreases the average age and complexity of habitat "patches," while isolating remnants of older natural forest (Hunter 1990; Freedman et al. 1994; Hagan et al. 1997; McRae et al. 2001). Landscape-scale forest management must accommodate species with extensive and specialized habitat needs, including some cavity-nesting birds dependent on older forest (Renken and Wiggers 1989, 1993; Bull and Holthausen 1993; Freedman et al. 1996; Bonar 2000).

Because of the specialized need of cavity-users for critical habitat, they are often considered indicators of the ecological sustainability of forest management (Angelstam and Mikusinski 1997). It is particularly important to maintain the habitat used by "keystone" primary excavators, such as older heart-rotten trees and snags, because a diverse group of secondary users depends on the cavities they create (Freedman et al. 1996; Martin and Eadie 1999). The Pileated Woodpecker (*Dryocopus pileatus*) is one example of a keystone excavator whose abandoned cavities are used by other species for nesting or roosting (Bull and Jackson 1995; Bonar 2000).

The effects of forestry on cavity-users are relatively wel known for forest types of the eastern and northwestern United States (Raphael and White 1984; DeGraaf and Shigo 1985; Zarnowitz and Manuwal 1985; Renken and Wiggers 1989; Connor et al. 1994). However, much less information is available on which to base management decisions in the north-temperate and boreal regions of eastern Canada. This deficiency is important because habitat needs of cavity-nesters vary geographically and are likely to be different in boreal and Acadian forest than in other regions and biomes (Parker et al. 1999). In recognition of this dearth of information, studies were initiated in the mid-1990s of cavity-nesting birds in eastern Canada, with the intent of informing management guidelines to conserve their populations (Doyon et al. 1999; Naylor et al. 1999; Bonar 2000; Flemming et al. 2000). This advice is greatly needed, because of the increasing areas of natural forest that are being intensively managed for timber production in eastern Canada.

Within this context, our study examines effects of forestry on cavity-dependent birds in a region of Acadian forest in southern New Brunswick. We assessed the degree to which cavity-nesting birds use conifer plantations and less-intensively managed stands, compared with natural forest. This was done by conducting breeding surveys of these habitats and by comparing occupancy of nest boxes as an indicator of limitation by natural cavities.

Study Area

The study area is in southeastern New Brunswick, Canada. It is located in the Atlantic Maritime Ecozone (Ecological Stratification Working Group 1995), within the Fundy Plateau Ecodistrict of the Acadian Forest Region (Loucks 1962; Rowe 1972). The climate is humid temperate and the natural forest is dominated by mixed-species stands of Red Spruce (*Picea rubens*), White Spruce (*P. glauca*), Balsam Fir (*Abies balsamea*), Sugar Maple (*Acer saccharum*), Red Maple (*A. rubrum*), Yellow Birch (*Betula alleghaniensis*), White Birch (*B. papyrifera*), and Mountain Birch (*B. cordifolia*). Extensive natural disturbances, including irruptions of native Spruce Budworm (*Choristoneura fumiferana*), have affected the natural forest, which tends to have a mixed-species canopy with gap-phase regenerating patches. Superimposed on the natural disturbance regime is a complex of anthropogenic influences. This began with the selective harvesting of large trees for lumber and ship-building, followed by extensive deforestation for agricultural development, then abandonment of most poorer-quality farmland beginning in the 1920s, and more recently the widespread establishment of conifer plantations.

Our study area is within the Greater Fundy Ecosystem (GFE), a region consisting of Fundy National Park and its surrounding area. The GFE was defined to study ecological consequences of the insularization of Fundy National Park, a 204 km^2 protected area embedded within a landscape whose matrix is being transformed by the conversion of natural forest into conifer plantations (Woodley et al. 1993, 1998; Freedman et al. 1994). The GFE itself is within the Fundy Model Forest (FMF), one of ten "model forests" established to demonstrate "sustainable forestry" in Canada. One declared indicator of sustainability in the FMF is that, at the landscape level, native biodiversity must not be compromised by forest management (Parker et al. 1999).

Methods

Stand selection

We selected 18 stands for study (see Table 1), including representative natural (or "reference") forest and habitats resulting from various intensities of management, including:

- five reference stands of unmanaged mature forest, including three mixed woods (dominated by Red Spruce (*Picea rubens*), Balsam Fir (*Abies balsamea*), and White Birch (*B. papyrifera*), and Mountain Birch (*B. cordifolia*) and two softwood dominated by Red Spruce;
- ten stands that had been clear-cut and then intensively managed to develop conifer plantations ranging from 5 to 19 years in age (the oldest available in the study area); eight were planted with Black Spruce (*Picea mariana*), one with Jack Pine (*Pinus banksiana*), and one with Norway Spruce (*Picea abies*);
- two selectively harvested stands (1-year-old and 12-years-old);
- one 30-year-old naturally regenerated clear-cut.

TABLE 1. General habitat characteristics of stands surveyed for cavity-nesting birds.

Site	Survey Year	Area (ha)	Stand description
Reference mixedwood forest			
Ra	1994	10	mature/mixedwood forest; Red Spruce, Balsam Fir, White Birch
Rb	1995	20	mature/mixedwood forest; Red Spruce, Balsam Fir, White Birch
Rc	1994	10	mature/mixedwood forest; Red Spruce, Balsam Fir, White Birch
Rd	1994	10	mature/Red Spruce-dominated forest
Re	1995	20	mature/Red Spruce-dominated forest
Plantations			
P5a	1994	10	5-year-old Black Spruce plantation
P5b	1994	10	5-year-old Norway Spruce plantation
P7	1995	20	7-year-old Black Spruce plantation with residual snags
P8	1994	10	8-year-old Black Spruce plantation
P9a	1994	10	9-year-old Black Spruce plantation
P9b	1994	10	9-year-old Jack Pine plantation
P15	1995	8	15-year-old Black Spruce plantation with residual snags
P17	1994	10	17-year-old Black Spruce plantation
P18	1995	10	18-year-old Black Spruce plantation
P19	1994	10	19-year-old Black Spruce plantation
Selectively harvested stands			
S12	1995	20	12-year-old selection harvested stand
S1	1995	20	1-year-old selection harvested stand
Naturally regenerated clear-cut			
NR30	1995	20	30-year-old naturally regenerated clear-cut with residual snags

Note that selected study stands were not always paired because of the lack of availability of suitable stands that were given the same management. The study plots affected by forestry were essentially operational stands embedded in a dissimilar habitat matrix generally of mixed-wood forests, and they were surveyed in their entirety. The reference plots were of a size and shape comparable to forestry-affected plots. The study stands were no more than 20 km from each other. Fieldwork was done during 1994 and 1995.

Habitat description

Trees (≥5 cm diameter at breast height (DBH) and >1.5 m tall) and snags (standing dead trees) were sampled in twelve quadrats (20 m × 20 m) arranged as a grid across the study plot. However, in plantations 15 years and older, smaller quadrats (10 m × 10 m) were used because of the uniform structure of tree-sized vegetation. Shrubs (<5 cm DBH) were measured for diameter at 25 cm in two 5 m × 5 m sub-quadrats in opposite corners of each tree-quadrat. Length and diameter of coarse-woody debris (CWD; >5 cm diameter) were also measured in tree-quadrats. The field data were used to calculate the average DBH and basal area by species, including snags, and the volume of CWD.

The cover of species of ground vegetation was determined in 30 randomly located 1 m^2 quadrats per site. The cover of overhead canopy was estimated as the percentage area obscured by foliage when sighting upward through a 4.2-cm diameter cylinder. Here we present summary information; detailed data on woody habitat are in Flemming and Freedman (1998) and on ground vegetation are in Veinotte et al. (2004).

Abundance of birds

Cavity-nesting birds were surveyed by modified spot-mapping to identify territories (Bibby et al. 1999). Habitat use was designated as "nesting territory" if we found evidence of a nest, and as "present" if a nest site could not be located. The surveys were conducted in plots with areas of 8 to 20 ha (Table 1). Ten stands were surveyed in 1994 and eight in 1995, and each was examined seven times from early June through to early July. The locations of calling or singing male birds were mapped in the study plots and also in adjacent habitat, and territorial boundaries were estimated using standard spot-mapping procedures (Bibby et al. 1999). Where possible, we recorded the sex, age (adult/juvenile), and relevant activity (nesting, feeding young, foraging, drumming, singing, calling) of individuals. This information contributed to the assignment of breeding territories.

Nest-box survey

To indicate whether cavities were a limiting factor for dependent species, we installed arrays of 12 nest boxes in each of seven plantations and three reference stands. The nest boxes were made of sections of White Cedar (*Thuja occidentalis*) with natural heart rot and were divided into three sizes: small (3.5-cm diameter entrance hole; ca. 6.5-cm internal width by 16 cm height), medium (6-cm hole, 11 × 34 cm), and large (9-cm hole; 15 × 48 cm). Because the site location and orientation of the entrance hole can affect occupancy (Rendell and Robertson 1994), these factors were standardized. Each nest box was mounted on an aspen pole supported by three steel cables fixed to

rebar pegs, and was placed at a predetermined height (small cavities at 2.5 m, medium at 3 m, and large at 5 m) with the entrance hole facing south. A total of 12 nest boxes was placed in each stand; two of each of size were positioned at 30 m and again at 100 m from a stand edge. The nest boxes were surveyed seven times during each of the 1994 and 1995 breeding seasons, and once late in the summer. We recorded the numbers of eggs, hatchlings, and fledglings of any species occupying the boxes, as well as roosting birds and non-avian species.

Data analysis

Because the study plots were unique habitats in terms of location, site and habitat attributes, and disturbance history, they were not treated as true statistical "replicates" (Hurlbert 1984; Heffner et al. 1996). Moreover, many of our data did not meet assumptions of normality or homegeneity of variance. Consequently, we restricted our analyses to simple comparisons among classes of habitat types. Relationships among stands were examined using multivariate analyses, with data input being matrices of species abundance by site (Kovach 1995). A cluster analysis was used to identify groupings of stands (or "communities"), using an unweighted pair-group procedure with arithmetic averages (UPGMA; Sokal and Rohlf 1995). Chi-square contingency tests were used to test for differences in occupancy rate of nest boxes between (a) unmanaged and managed stands and (b) boxes located at 30 m or 100 m from a forest edge.

Results and Discussion

Habitat

The stands of natural (reference) forest had a large basal area (an indicator of biomass) of trees compared with the other habitats studied (Table 2). Although a high tree density occurred in older plantations and the naturally regenerated site, these were smaller trees than in natural forest. The species composition of the natural forest was mixed, whereas the plantations are more strongly dominated by the planted conifer species. The natural forest also had relatively abundant snags. Of the various managed stands, only the 7-year-old and 15-year-old plantations (P7 and P15, respectively) had many snags, because the pre-harvest snags had not all been removed or felled during the clear-cut, and a subsequent herbicide treatment killed surviving hardwood trees. The 30-year-old naturally regenerated clear-cut also had abundant snags, as did the 12-year-old selectively harvested site. Coarse-woody debris was abundant in the stands of reference forest, where it originated as natural deadfall. Coarse-woody debris was also abundant in the plantations and selectively harvested stands, where it mostly originated as logging slash and, in older plantations, trees cut and left during a non-commercial thin. Similar but more detailed observations have been made by other studies of natural forest and plantations in our study area (Flemming and Freedman 1998).

TABLE 2. Summary of key habitat data (presented as mean area).

	Reference Stands					Plantations										Selection		Nat'l Regen
	Ra	Rb	Rc	Rd	Re	P5a	P5b	P7	P8	P9a	P9b	P15	P17	P18	P19	S1	S12	NR30
Tree Basal Area (m^2/ha)																		
Conifers	18.3	18.3	19.0	30.3	30.2	0.0	0.0	0.0	0.0	0.2	3.2	8.9	10.8	26.3	15.0	0.0	8.7	20.2
Hardwoods	10.9	10.9	6.4	10.7	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.1	0.0	7.9	2.7
Snags	6.1	3.6	11.4	5.1	5.0	0.0	0.0	3.8	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.7	2.0
Tree Density (10^3/ha)																		
Conifers	0.6	0.6	1.0	0.9	0.9	0.0	0.0	0.0	0.0	0.1	0.9	2.4	3.0	4.7	2.3	0.0	0.5	2.6
Hardwoods	0.5	0.5	0.2	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.4
Snags	0.2	0.2	0.7	0.5	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2
Shrub Basal Area (m^2/ha)	0.2	0.2	1.5	1.2	1.1	2.6	2.1	1.4	2.2	4.8	5.6	3.2	3.3	3.3	4.2	0.7	2.9	2.4
Coarse-Woody Debris (m^3/ha)	23.0	23.2	45.4	22.6	22.9	83.7	47.8	30.5	21.3	31.1	16.2	12.3	11.2	40.1	20.1	40.2	15.8	7.1

TABLE 3. Abundance and species richness of cavity-nesting birds. Data are standardized as territories per 10 ha; + indicates <0.5 territory; P indicates the species was present on the site. REFERENCE refers to natural, mature, mixed-species forest; PLANTATION refers to intensively managed conifer plantations; SELECTION refers to sites that were selectively harvested; NAT REGEN refers to a 30-year-old naturally regenerated clear-cut. Numbers associated with site name-codes indicated the number of years since the original forest was harvested.

Species	Reference					Plantation										Selection		Nat'l Regen
	Ra	Rb	Rc	Rd	Re	P5a	P5b	P7	P8	P9a	P9b	P15	P17	P18	P19	S1	S12	NR30
Kestrel								0.5	1			+						
Barred Owl					P													
Saw-whet Owl		+																
Yellow-bellied Sapsucker	P	+	P	P												+	0.5	
Downy Woodpecker	P	P	1	1	0.5											0.5	P	P
Hairy Woodpecker	P	P		P				P								+	P	
Black-backed Woodpecker	P		P															
Northern Flicker	P	P			P	P	1	0.5		1	P	1.0	P	P	P	+		
Pileated Woodpecker	P	P	P	P	+													
Tree Swallow							1											
Black-capped Chickadee	2	2	2	P	1								P		P	2.0	1.5	P
Boreal Chickadee	1	1	1	P	1.5							3.0	P		1	P		1.5
Red-breasted Nuthatch	1	2	P	P	1.0							P			P	1.5	0.5	1.0
White-breasted Nuthatch				P														
Brown Creeper	P	0.8	P	1	0.5			+							P	1.0		
Winter Wren	3	1.5	P	1	0.5												P	+
Total Territories	7.0	7.3	4.0	3.0	5.0	0.0	2.0	1.0	1.0	1.0	0.0	4.0	0.0	0.0	1.0	5.0	2.5	2.5
Species Richness	11	11	9	10	9	1	2	4	1	1	1	4	3	1	5	8	6	5

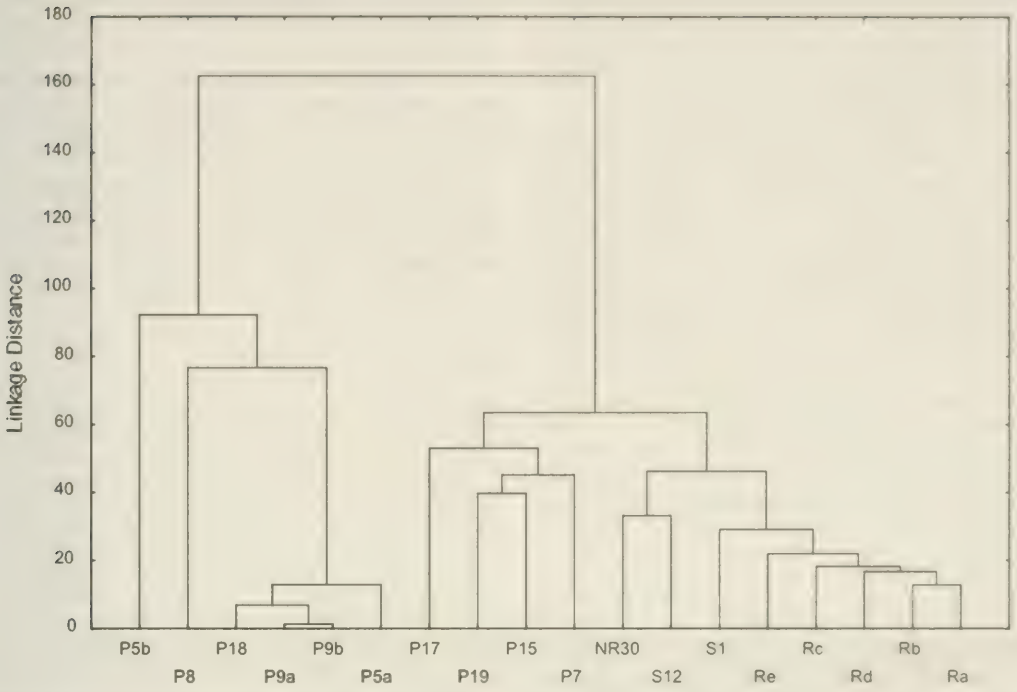

FIGURE 1. Cluster analysis of stands based on their species and abundances of cavity-nesting birds. See Table 1 for explanation of site codes.

The abundance and cover of shrubs and ground vegetation were highly variable among stands (Table 3). In general, these vegetation elements were more abundant in the plantations and other harvested stands, which were in younger stages of secondary succession than the more mature natural forest. Similar, but more detailed observations of forest and plantations in our study area have been made by Veinotte et al. (2004).

Cavity-nesting Birds

A total of 16 species of cavity-nesting birds was observed (Table 3). The most abundant species were the Black-capped Chickadee (24% of the territories; see Appendix 1 for avian binomials), Boreal Chickadee (23%), Red-breasted Nuthatch (16%), and Winter Wren (14%). The species richness was higher in the natural forest (average of 10.0 species per stand; total of 14 species present in the habitat type) than in plantations (2.3/stand; 8 species present), selectively harvested stands (7.0/stand; 9 species present), or the naturally regenerated clear-cut (5.0/stand). Abundance was also higher in the reference forest (average 5.3 territories/10 ha) than in plantations (1.0/10 ha), selectively harvested stands (3.8/10 ha) or the naturally regenerated clear-cut (2.5/10 ha). Among the ten plantations studied, the highest density of cavity-nesting birds was in P15 (4.0 territories/10 ha), which also had a relatively large number of snags (2.1 m^2/ha compared with an average of 0.4 m^2/ha among the other nine plantations).

A cluster analysis segregated the "community" of cavity-nesting birds of the natural forest from those of the other treatments (Figure 1). In the cluster analysis, the five reference stands were arranged together on the right-hand side. The selectively harvested stands (S1 and S12) and naturally regenerated stand (NR30) had relatively abundant cavity-nesting birds and clus-

TABLE 4. Cavity-using species encountered in this study.

American Kestrel	*Falco sparverius*
Barred Owl	*Strix varia*
Northern Saw-whet Owl	*Aegolius acadicus*
Northern Flicker	*Colaptes auratus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Black-backed Woodpecker	*Picoides arcticus*
Pileated Woodpecker	*Dryocopus pileatus*
Tree Swallow	*Tachycineta bicolor*
Black-capped Chickadee	*Poecile atricapillas*
Boreal Chickadee	*Poecile hudsonicas*
Brown Creeper	*Certhia americana*
White-breasted Nuthatch	*Sitta carolinensis*
Red-breasted Nuthatch	*Sitta canadensis*
Wood Duck	*Aix sponsa*
Winter Wren	*Troglodytes troglodytes*

tered close to the reference stands. Of the plantations, those with relatively abundant and species-rich cavity-nesting birds clustered together (i.e., P7, P15, P19, and P17), while the most depauperate ones formed another cluster (i.e., P5b, P8, P9a, P9b, P5a).

The observation that cavity-nesters are more abundant in mature mixedwood forest than in harvested stands or plantations is consistent with research elsewhere, although the specifics vary depending on the forest region and species of birds present (e.g., Raphael and White 1984; DeGraaf and Shigo 1985; Zarnowitz and Manuwal 1985; Hansen et al. 1995; Kirk and Naylor 1995; Niemi et al. 1998; Hobson and Bayne 2000).

Of the 16 species of cavity-nesting birds recorded during our study, eight were not recorded in any of the plantations: Saw-whet Owl, Barred Owl, Yellow-bellied Sapsucker, Downy Woodpecker, Black-backed Woodpecker, Pileated Woodpecker, White-breasted Nuthatch and Winter Wren. One species, the Tree-Swallow, was only recorded as breeding in plantations in which nest boxes were present.

Nest-box Occupancy

Nest boxes were used by five species for nesting and by four for roosting (Table 4). Tree Swallow accounted for 41% of the nests, American Kestrel 31%, and Boreal Chickadee 17%. The most frequently roosting species were Tree Swallow (48%) and Northern Flicker (33%). The use of nest-boxes for nesting was much greater in plantations (average 4.0/10 ha) than in the natural forest (0.3/10 ha), and similarly for roosting (average 2.9/10 ha in plantations and 0.3/10 ha in reference stands). Overall, 33% of the nest boxes in plantations were used for nesting or roosting (28 of 84 boxes with nests), compared with only 3% in natural forest (1 of 36 boxes with nests). These observations support the notion that suitable cavities are a limiting factor in plantations in the study area, compared with the natural forest. The plantations we studied appear to provide suitable habitat for foraging and other purposes, but can only be used for nesting and roosting by cavity-dependent birds if their need for cavities is met. There were no recorded cases of a failed nest in the nest boxes.

Of the 28 nest boxes used for nesting in plantations, 7.5% were located 30 m from an intact forest edge and 15.8% were 100 m from such an edge (marginally significant difference; $\chi^2 = 3.78$, 1 df; $>0.05 < P < 0.1$). The apparent reluctance to use nest-boxes located closer to a habitat edge may be associated with a greater risk of predation (Paton 1994; Derochers and Hannon 1997).

Implications for Management

It appears that conifer plantations in our study region can recover bird populations rather quickly after establishment, but the species composition is different from that of natural forest, and cavity-dependent species are present in low abundance (Freedman et al. 1994; Freedman and Johnson 1999; Johnson and Freedman 2002). Moreover, observations and models of stand development suggest that intensively managed plantations are depauperate in snags, cavity-trees, and coarse-woody debris and are likely to remain so over subsequent rotations because the harvesting removes all large-dimension tree biomass (Flemming and Freedman 1998). These changes do not augur well for cavity-dependent species in stands and landscapes extensively converted into forestry plantations.

Clearly, the extensive conversion of mixedwood Acadian forest into conifer plantations will result in a decline in the abundance and species richness of cavity-dependent birds at the scales of both stand and landscape. Certain site mitigations might help some species, particularly the retention of some snags and large living trees within plantations, or much less preferably, the provision of nest boxes to provide local nesting and roosting habitat (Welsh and Capen 1992; Newton

TABLE 5. Use of nest boxes in plantations and reference forest during two study years. Each site had an array of 12 nest boxes, each made of a section of a hollow log of White Cedar. All plots were 10 ha in area. Note some stands from Table 3 had no nest boxes installed, so the number of stands differs between Table 3 and 4.

Species	Reference			Plantation						
	Ra	Rc	Rd	P5a	P5b	P8	P9a	P9b	P17	P18
Nesting										
Wood Duck				1						
American Kestrel				2	2	2	2	1		
Northern Flicker					1	1				
Tree Swallow				2	3	3	3		1	
Boreal Chickadee		1							2	2
Total nests	0	1	0	5	6	6	5	1	3	2
Roosting										
American Kestrel					1		2			
Pileated Woodpecker			1							
Northern Flicker					1		3	2	1	
Tree Swallow					2	5	3			
Total roosting	0	0	1	0	4	5	8	2	1	0

1994; Flemming et al. 2000). It is likely, however, that these site mitigations will not be sufficient to maintain some cavity-dependent species, particularly those with large home ranges that encompass a mosaic of habitat patches, such as Pileated Woodpecker (Bonar 2000; Flemming et al. 2000). These species will require large protected areas of unmanaged forest to function as population centres.

Without sympathetic management of this sort, it is likely that the population viability of some cavity-dependent birds in regions extensively managed for forestry will become compromised. Some jurisdictions have established guidelines to help these species — in New Brunswick, for example, timber companies operating on Crown Land are to required to retain at least 10% of conifer-dominated forest in mature or older successional stages, in patches of 500 or more ha (Sullivan 1996). However, these requirements may not be adequate to maintain critical habitat for all species of cavity-nesting birds, particularly keystone primary excavators (Flemming et al. 2000). It is essential that these conservation guidelines be monitored to ensure they achieve their intended ecological purpose, including the maintenance of viable populations of all cavity-dependent species. In the meantime, a precautionary approach to ecologically sustainable forestry would require that additional large areas of natural forest be set aside from intensive economic use, as parks or other kinds of protected areas.

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Recent Invasion, Current Status and Invasion Pathway of European Common Reed, *Phragmites australis* subspecies *australis*, in the Southern Ottawa District

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Catling, Paul M., and Susan Carbyn. 2006. Recent invasion, current status and invasion pathway of European Common Reed, *Phragmites australis* subspecies *australis*, in the southern Ottawa district. Canadian Field-Naturalist 120(3): 307–312.

A survey of populations of native North American Common Reed (*Phragmites australis* subsp. *americanus*) and the introduced invasive alien, European Common Reed (*Phragmites australis* subsp. *australis*) was conducted in four eastern Ontario townships in 2003. The historical status of the two taxa in the region was evaluated through reference to herbarium specimens collected over the past century. The introduced subspecies appears to have entered the district in the 1970s and subsequently assumed dominance but was not recognized as an alien until 2003. It is now widespread in the four townships where ninety-five populations were recorded during the 2003 survey. Of these, 25 were referable to the native subspecies which was localized and 70 were referable to the introduced subspecies which was widespread. The native subspecies occurs in natural wetlands and also spreads to roadsides, but the introduced subspecies is much more strongly associated with roads, where the rhizomes extend onto gravel shoulders and are broken and transported by construction equipment, graders, ploughs, mowers, and in the treads of many kinds of vehicles. Sensitive wetlands should have buffer zones exceeding 1000 m to prevent colonization of subsp. *australis*. Monitoring of the two subspecies will be essential to the protection of native biodiversity, since early detection of the alien subspecies in a sensitive wetland will offer the best opportunity for control.

Key Words: North American Common Reed, *Phragmites australis* subsp. *americanus*, European Common Reed, *Phragmites australis* subsp. *australis*, invasion pathway, alien, invasive species, Ottawa, Canada.

One of the most productive plants in temperate regions, Common Reed, *Phragmites australis* (Cav.) Trin. *ex* Steud. has economic and agricultural values and is under-exploited (Small and Catling 2001). Domestication and introduction of non-native races however, pose some potential risks to both agriculture and environment. It is a major pest of irrigation and flood control channels in some parts of the world and, being able to grow in water 2 m deep or on dry ground, it is not readily controlled by drawdown.

It was only recently realized that both native and introduced races existed in North America (Catling et al. 2003). The native plants have been designated subspecies *americanus* Saltonstall, P. M. Peterson & Soreng (Saltonstall et al. 2004) and the introduced plants identified as subspecies *australis* (Catling 2006, 2007, Catling et al. 2007). It is believed that the introduced subspecies *australis* originated from southern Europe. It has been recently recognized as a major threat to North American biodiversity (Chambers et al. 1999; Meyerson et al. 2000; Catling et al. 2003; Robichaud and Catling 2003; Catling 2005). In a recent survey of the St. Lawrence River wetlands it was found to have a greater impact on native plant diversity than most other invasive aliens including Purple Loosestrife, *Lythrum salicaria,* (Lavoie et al. 2003). The subspecies *australis* is currently spreading in Canada from areas of concentration in southern Ontario and southern Quebec and has only recently been reported from western Canada (Martin 2003; Schueler et al. 2003) and the maritime provinces (Catling et al. 2004).

In eastern Ontario the alien subspecies *australis* was first recognized in 2003, but it apparently invaded the area a few decades earlier. Local botanists noticed the rapid spread of dense stands of *Phragmites* beginning in the 1970s and the rapid change from the status of a locally rare plant (Dore 1959) created suspicion about the possibility of an introduced race. Preliminary observations suggested that it spread into the region along roads very recently and became widespread. Here we analyse its apparent recent spread into the region along roads by providing information on its history of invasion, current status and invasion pathway in the southern part of the Ottawa district based on identification of herbarium specimens and a current survey of populations in four adjacent townships. This work will also provide benchmark data for analysis of future changes in status of native and introduced subspecies, thus contributing information needed to predict rate of spread and impact.

Methods

A recent study of plants of *Phragmites australis sensu lato* in eastern Ontario suggested that plants with lower glumes exceeding 4.2 mm long were referable to the native subspecies *americanus* (Robichaud and Cat-

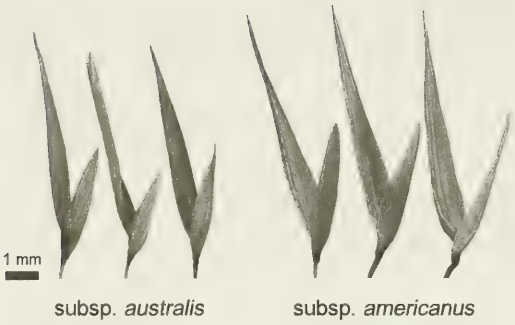

FIGURE 1. Glumes of *Phragmites australis*. The smaller on the right of each attached pair is the lower glume, whereas the longer glume on the left of each pair is the upper glume. The subspecies *australis* on the left has shorter lower glumes as represented by three examples from an inflorescence of a specimen from Dundas County (*Catling and Robichaud*, 10 Oct. 2002, DAO). On the right are three pairs from an inflorescence of subspecies *americanus* from Leeds and Grenville County (*Catling and Kostiuk*, 30 Aug. 2003, DAO) showing its characteristically longer lower glumes.

ling 2003). More recent work based on correlation with basal stem color and date of collection (Saltonstall et al. 2004; Catling and Mitrow *in press*) has supported the separation using 4.2 mm for length of longer glumes, this separation being correct (i.e. correlated with other diagnostic features) 97.3% of the time (Figure 1). Most recently (Catling 2006) the following key has been recommended for distinguishing the two subspecies:

Basal internodes red or reddish-purple; longer lower glumes 3.8-7 mm long . . . . . subspecies *americanus*

Basal internodes pale yellow; longer lower glumes 2.6-4.2 (4.8) mm long . . . . . subspecies *australis*

For the study reported here undertaken in 2003, we used a length of 4.2 mm or more to identify the native subspecies *americanus* and 4.1 mm or less to identify the introduced subspecies *australis* in a survey of four adjacent geographic townships (Figure 2): Russell (45.2833°N, 75.2833°W), Osgoode (45.2333°N, 75.5000°W), North Gower (45.1500°N, 75.6833°W) and Marlborough (45.0666°N, 75.8166°W). Hybrid-like or intermediate clones were not observed during this study but several were located subsequently in townships to the north.

The survey was conducted in May 2003 at which time the persistent flowering stalks of the previous year were readily visible on the landscape and the persisting inflorescences were not so damaged as to prevent measurement of first glume lengths. The survey included driving all roads in each township, checking known locations and searching larger open wetlands in Rideau Township on foot. All small wetlands visible from roads were examined with binoculars. Location of populations was recorded with GPS and size of patches and number of flowering stalks and distance from road were also recorded. Populations were defined as less than 500 m apart or 500 m in length. A voucher inflorescence from one of the tallest flowering stems was collected from each population and from these vouchers the length of the longest first glume of 25 examined was recorded. Voucher specimens for some the collections were deposited in the AAFC [Agriculture and Agri-Food Canada] vascular plant collection (acronym DAO ["Department of Agriculture, Ottawa"]). All flowering culms within individual stands were similar and were assumed to represent single clones.

Collections in Canadian herbaria from Ottawa area and Carleton and Prescott counties were identified to race (using criteria described above) in order to determine status of the two subspecies in the region in the past. The historical information was compared to maps of the occurrence of the native and introduced

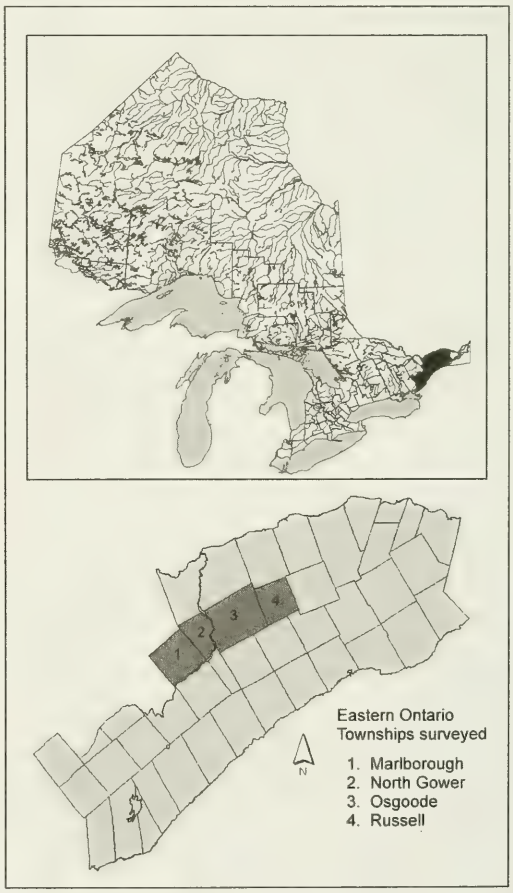

FIGURE 2. Location of four adjacent townships in eastern Ontario where native and introduced subspecies of *Phragmites australis* were surveyed and mapped in May 2003. Inset map above shows eastern Ontario and Great Lakes with Eastern Ontario region shown in black.

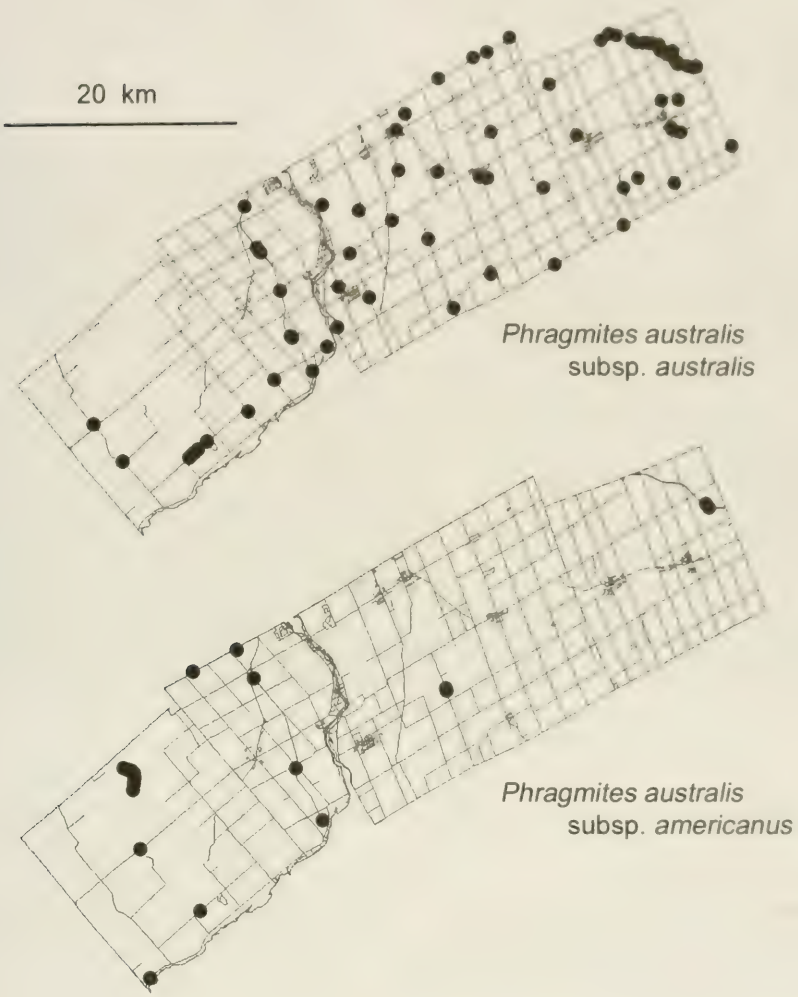

FIGURE 3. Distribution of native and introduced subspecies of Common Reed *Phragmites australis* in four eastern Ontario townships based on a survey in May 2003. Aove, introduced Eurasian subspecies *australis*. Below, native North American subspecies *americanus*.

subspecies in the four townships based on the results of the 2003 survey.

The relationship to roads was analysed by comparing the distribution of both subspecies by plotting on township maps showing roads using histograms showing frequency of various distances from roads. In order to further elucidate the history of spread, the size of patches was compared on major and minor roads, all at least 20 years old, in Russell township.

Results

History of Invasion

In Canadian herbaria there are 45 specimens of *Phragmites australis* collected in the southern portion of the Ottawa district (Ottawa-Carleton Regional Municipality and Prescott-Russell counties). Of these, 21 collected prior to 1970 are referable to the native subspecies. The earliest collection of the introduced subspecies was in 1976 at Manotick (*Hanes*, DAO). Of the 24 specimens collected after 1970, only five are referable to the native subspecies, the remainder having the relatively short first glumes of the introduced subspecies. Thus the introduced subspecies appears to have entered the district in the 1970s and subsequently assumed dominance but was not recognized as an alien until 2003 (Catling et al. 2003).

Present Status

Ninety-five populations were recorded in the four townships during the 2003 survey. Of these, 25 were referable to the native subspecies and 70 were referable to the introduced subspecies. Both subspecies

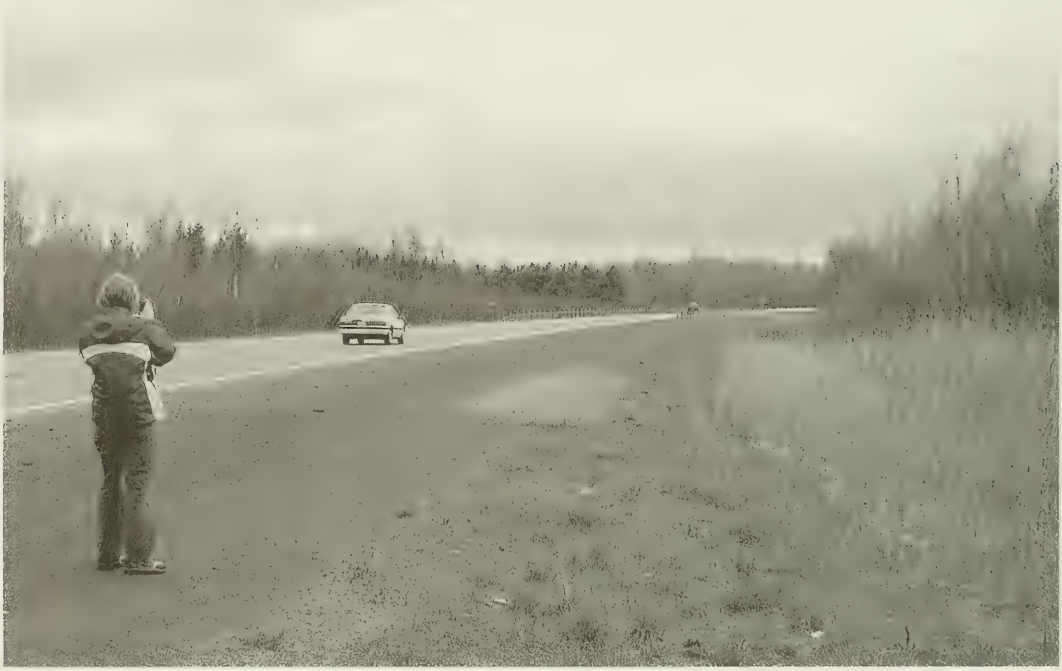

FIGURE 4. Patch of pale stems of *P. australis* subsp. *australis* on gravel portion of a roadside and extending in a large clone in the adjacent ditch and swamp. Highway 417, Russell Township, May 2003.

occurred in all four townships, but the native subspecies was much more localized, with most populations in a single wetland (Figure 2).

Invasion Pathway

As seen in the distribution maps (e.g. Figure 3) there is a strong association of the introduced subspecies with roads (Figure 4). This is confirmed in the histogram (Figure 5) where the vast majority of the populations of the introduced subspecies are within 100 m of a road. In fact 52% were in the roadside gravel (Figure 4) and 84% were within 3 m of the boundary between vegetation and gravel shoulder. Populations of the native subspecies occurred at greater distances from a road (Figure 5) with 36% on the shoulder and 60% within 3 m. Although occurrence of the native subspecies on roadsides was much less, it is clearly spreading from natural habitats to roadsides. Since both subspecies may come into close contact on roadsides, there is an opportunity for the subspecies to hybridize. The introduced subspecies was most frequent in the eastern townships that have the most roads (Figure 3). The native subspecies was most frequent in the far western township which has the least extensive road network and the most extensive natural wetlands.

Major concentrations of the introduced subspecies occurred along Highway 417 (upper right in Figure 3), the busiest and oldest major highway in the region, and the largest patches in Russell township occurred along this road, suggesting that this is one of the places where it first entered the region (Figures 3 and 6). The association of the introduced subspecies with roads suggested spread by dispersal of rhizomes by road vehicles rather than wind-blown seed which would have resulted in more occurrences at greater distances from roads. The tough rhizomes extend into the gravel shoulders and even onto the asphalt (Figure 4). They are readily broken and transported by ploughs, graders and in the tire treads of many kinds of vehicles (personal observation). This mechanism of dispersal is believed to be largely responsible for the rapid spread and present strong association with roads.

There is a possibility that spread along roads is facilitated by relatively high sodium salt (NaCl) concentrations, as noted for many other vascular plants spreading along roadsides (e.g. Catling and McKay 1980, 1981; Reznicek and Catling 1987). Salt concentrations may reduce competition by eliminating other species, thus promoting salt-tolerant species. Although the alien subspecies may be tolerant of relatively high salt concentrations, reliance on salty habitats is probably much less than for other rapidly spreading roadside plants such as *Carex praegracilis* (e.g., Reznicek and Catling 1987). Some patches of the alien subspecies of Common Reed do occur at great distances from roads and some roadside patches extend up to 100 m from roads beyond the influence of sodium salt.

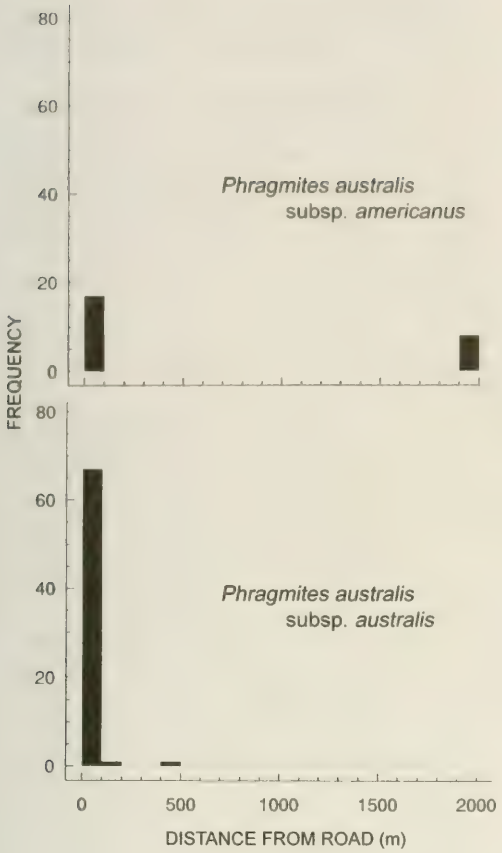

FIGURE 5. Histograms showing frequency of distances from major and minor roads of native and introduced subspecies of *australis* in four eastern Ontario townships.

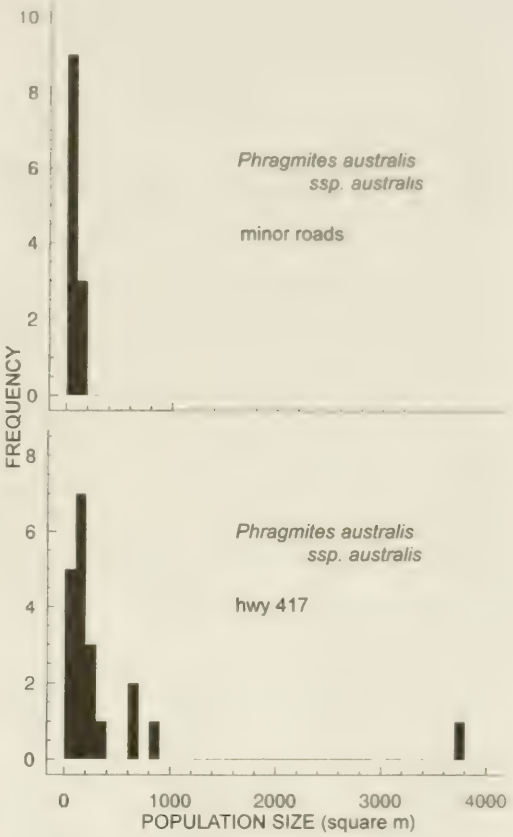

FIGURE 6. Histograms showing frequency of clone sizes of the introduced *Phragmites australis* subspecies *australis* in relation to major and minor roads in Russell Township.

Further evidence for a lack of strong dependence on sodium salt is the observation that the alien subspecies of Common Reed occurred along many minor and gravel roads that do not receive applications of deicing salt.

The introduced subspecies has colonized two natural wetlands in the study area without spreading from a roadside. One of these stands is 500 m from a road along a pond shore used extensively as a staging area by waterfowl. This colonization may have been the result of transport of rhizomes by the waterfowl, which occurs with many aquatic plants, but is unusual. Once in a wetland system the rhizomes are likely to be transported further by aquatic mammals and birds for building habitations, platforms and nests. Successful germination of wind-dispersed seed is also a possibility, but strong association with roads suggests that it happens infrequently. Both native and introduced populations produce apparently viable seed with quantities varying between poplulations (personal observation, Catling). As alien Common Reed increases on the landscape the frequency of unusual dispersal mechanisms is likely to increase, and spread through wetlands may increase substantially.

Future Spread

Considering that it is being spread by road vehicles along corridors of essentially continuous habitat, including new and disturbed habitats, the rate of spread can be anticipated to be rapid. *Carex praegracilis* W. Boott is believed to have spread the same way throughout much of eastern North America from the midwest in only 30 years (e.g., Reznicek et al. 1976; Reznicek and Catling 1987). Since the introduced subspecies of *Phragmites australis* has apparently spread from roadsides to distances of up to 500 m from roads (Figure 5), it appears that it is not confined to the near road environment. Although it seems less likely that the introduced subspecies will invade sensitive wetlands through introduction by waterfowl, the chances will increase as it becomes more abundant. There are also

opportunities for spread into isolated wetlands through transport along tracks of off-road vehicles including motorcycles, ATVs and snowmobiles.

The introduced subspecies has extensively spread into both saline and non-saline wetlands and along both dry and wet roadsides in parts of the United States. Within another 10-20 years it is expected to line many major roadways in eastern Canada and it will have entered many wetlands from adjacent or nearby roads. As it spreads it is most likely to become established first along major roads, providing an early warning of future impact on the nearby landscape.

The introduction of invasive aliens into wetlands by roads provides another reason to have extensive buffer zones around wetlands with high protection priority. Considering that the vegetative spread of *P. australis* can be very rapid, and mammals and birds transport rhizome fragments over substantial distances for nesting, buffers exceeding 1000 m are desirable. Monitoring of the two subspecies will be essential to the protection of native biodiversity, since early detection of the introduced subspecies in a sensitive wetland will offer the best opportunity for control.

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Pack Size of Wolves, *Canis lupus*, on Caribou, *Rangifer tarandus*, Winter Ranges in Westcentral Alberta

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Kuzyk, Gerald W., Jeff Kneteman, and Fiona K.A. Schmiegelow. 2006. Pack size of Wolves, *Canis lupus*, on Caribou, *Rangifer tarandus*, winter ranges in westcentral Alberta. Canadian Field-Naturalist 120(3): 131–318.

We studied pack size of Wolves (*Canis lupus*) on Woodland Caribou (*Rangifer tarandus caribou*) winter ranges in westcentral Alberta. These Caribou winter ranges are experiencing increasing pressure from resource extraction industries (forestry, energy sector) and concerns have been raised regarding increased Wolf predation pressure on Caribou in conjunction with landscape change. Thirty-one Wolves, from eight Wolf packs, were fitted with radiocollars on two Caribou winter ranges in the Rocky Mountain foothills, near Grande Cache, Alberta (2000-2001). There was a mean of 8.2 Wolves/pack and between 30 and 39 Wolves on each of the RedRock/Prairie Creek and Little Smoky Caribou ranges. The average pack size of Wolves in this region does not appear to have increased over that recorded historically, but the range (5-18) in the number of Wolves per pack varied considerably over our study area. Wolves preyed predominately on Moose (*Alces alces*), averaging one Moose kill every three to five days. There was some indication that pack size was related to prey size, with the smallest pack preying on Deer (*Odocoileus* spp.). It was clear that Caribou could not be the primary prey for Wolves, due to their low numbers, and relative to the pack size and Wolf kills we observed.

Key Words: Wolf, *Canis lupus*, Caribou, *Rangifer tarandus*, Moose, *Alces alces*, White-tailed Deer, *Odocoileus virginianus*, predation, pack size, colour phase, kills, Alberta.

Pack size of Wolves (*Canis lupus*) can provide an important indication of ungulate abundance (Fuller 1989; Schmidt and Mech 1997; Hayes et al. 2003) and human impacts on the landscape (Mech 1995). The number of Wolves in each pack can be related to prey availability (Fuller 1989) and may be regulated by dispersal, pup survival and disease prevalence (Mech 1970; Mech et al. 1998). The amount of food available to each Wolf has been inversely related to pack size (Thurber and Peterson 1993; Schmidt and Mech 1997), with smaller pack sizes found in areas of low ungulate density (Messier 1985). In contrast, pack size may remain stable when the amount of food per Wolf decreases, possibly due to a genetic advantage for the breeding pair when sharing limited food with their offspring (Schmidt and Mech 1997). Maximum Wolf pack size may be regulated by behaviors within the pack, such as social dominance, which can facilitate dispersal. Pack size has also been related to prey size. Average pack size of Wolves hunting White-tailed Deer (*Odocoileus virginianus*) is generally less than seven (Mech 1970; Fuller 1989), whereas packs preying on Moose (*Alces alces*) are generally larger, having ten or more Wolves per pack (Peterson et al. 1984; Mech et al. 1998; Hayes et al. 2003). Vucetich et al. (2004) demonstrated that larger packs are better able to compete with ravens and do accrue a foraging advantage. Reports of large Wolf Packs with over 20 members have been documented in regions where there is little Wolf harvest (Hayes and Harestad 2000) or in protected areas (Carbyn et al. 1993; Peterson 1995; Mech et al. 1998; Smith et al. 2004).

Predators may negatively affect endangered prey species when landscapes become impacted by human disturbance (Schneider 2001). Landscapes in westcentral Alberta are facing increased pressures from forest harvesting and the energy sector (oil and gas). Forest harvesting may alter the movements and distribution of Wolves (Kuzyk et al. 2004) and ungulates (Smith et al. 2000), and in combination with linear corridors (roads, seismic lines) from oil and gas activities, can enhance human access to once remote areas and possibly increase human-caused Wolf mortality from shooting and trapping. Enhanced predation by Wolves, facilitated by landscape change such as increased travel efficiency on linear corridors (James and Stuart-Smith 2000) and associated increases in alternate prey populations (James et al. 2004), is thought to be the primary factor for Caribou declines in Alberta (Edmonds 1988; McLoughlin et al. 2003). In Alberta, Woodland Caribou (*Rangifer tarandus caribou*) are classed as a threatened species under the provincial Wildlife Act and on the Species at Rist Act Public Registry [SARA, http://www.sararegistry.gc.ca/species/SpeciesDetails_e.cfm?sid=636] and special management considerations are necessary to maintain numbers and habitat (Edmonds 1998; Dzus 2001). More information is required on Wolf populations, such as pack sizes, to be better able to predict long-term changes in the dynamics of Wolves and Caribou associated with land-

scape change (Weclaw and Hudson 2004). The objective of this paper is to present current information on pack size and associated predation by Wolves that can be used in decision-making processes for long-term Caribou conservation.

Study Area

The study area is approximately 5000 square kilometres, located in the foothills of west-central Alberta, near the town of Grande Cache (54°N 119°W). The area is classed into subalpine and boreal natural subregions (Beckingham and Archibald 1996), and contains several main rivers but lakes are scarce. Elevations range from 1300-1800 metres, and the climate is subarctic, with short wet summers and long cold winters. Temperatures average 16°C in July and -13.5°C in December (Beckingham and Archibald 1996). The forests are primarily Lodgepole Pine (*Pinus contorta*) and some White Spruce (*Picea glauca*). The wetlands support mostly Black Spruce (*Picea mariana*) and some Tamarack (*Larix laricina*). Some south facing slopes have Aspen (*Populus tremuloides*) and willow (*Salix* sp.).

The study area contains three major Caribou herds: the Red Rock/Prairie Creek and Al La Peche are mountain herds and represent a migratory ecotype, while the Little Smoky herd is boreal or sedentary ecotype (Edmonds 1988). Population size for the mountain herds is estimated at 600-750 Caribou (Edmonds 1998), and the Little Smoky herd is estimated at fewer than 100 animals (Smith 2004). The study area also supports a high diversity of other large mammals. Moose are found at densities ranging from 0.12 to 0.25 Moose per square kilometer (Alberta Fish and Wildlife unpublished data). Other ungulates occurring in the area are Elk (*Cervus elaphus*), Mule Deer (*Odocoileus heminous*), White-tailed Deer, Bighorn Sheep (*Ovis canadensis*), Mountain Goats (*Oreamnos americanus*) and Wild Horses (*Equus cabalus*). Wolves (*Canis lupus*), Coyotes (*Canis latrans*), Grizzly Bears (*Ursus arctos*), Black Bears (*Ursus americanus*) and Cougars (*Felis concolor*) also exist throughout the study area.

Wolf Captures and Monitoring

Wolf captures were conducted on two Caribou winter ranges in the winters of 2000 and 2001. Four Wolf packs were located on the winter range of a migratory mountain Caribou population (Red Rock/Prairie Creek herd) and four packs located on the winter range of a sedentary boreal Caribou population (Little Smoky herd) (Figure 1). Ungulate baits were placed in strategic locations seven to ten days prior to the initiation of the Wolf capture operation, to enhance detection of Wolves. Wolves were located by following trails in the snow from a fixed-wing aircraft (Mech 1966; Mech et al. 1998). All Wolf handling was approved by the Faculty of Agriculture, Forestry and Home Economics Animal Care Policy (Number 96-99D), subject to the protocols of the Canadian Council of Animal Welfare. Wolf captures were accomplished by either helicopter darting (Ballard et al. 1991) or netgunning, then physically restraining the Wolf with restraining forks, and hand-injecting 1-2 mls of telazol at 200mg/ml (Kuzyk 2002). Adults were distinguished from pups by tooth eruption patterns (Van Ballenberghe and Mech 1975) whereas yearlings were classed on subjective physical criteria (size), as there is no definitive method to categorize yearling Wolves (Mech et al. 1998). Adult Wolves were fitted with store-aboard GPS (Global Positioning System) collars (Lotek Engineering Systems, Newmarket, Ontario or Televilt GPS-Simplex, Lindesberg, Sweden) or VHF (Very High Frequency) radiocollars (Lotek Engineering). Pups were fitted with VHF collars only. All Lotek GPS collars were equipped with remote dropoff units, intended to release when signaled from the air. All radiocollared Wolves were relocated by aerial radiotracking (Mech 1974) within one to four days of capture to determine if they had rejoined their packs. Color phases of Wolves were recorded as gray, black, or white following Dekker (1986), and adding a category of blue.

Wolf pack size was recorded during aerial radiotracking in February and March of each year, when pack size would be at a minimum (Mech 1970), thus yielding a conservative estimate. Most packs were intensively monitored in March of 2000, increasing the chances of a good count. The best estimates of Wolf pack size were made when the Wolves were traveling in single file on a linear corridor or river. Lone Wolves were assumed to account for 10% of the total population (Fuller 1989). We did not extrapolate our pack size data to determine Wolf density, due to insufficient temporal data required to adequately determine annual territory sizes. In addition, our broader project objectives entailed studying Wolves in late winter, corresponding with winter range occupancy by migratory Caribou. It is the winter range of these caribou that is currently undergoing industrial development, and thus of primary conservation concern.

Wolf kills were determined during a two-week period in March 2000 by aerially locating radiocollared Wolf packs and finding their ungulate kills (Mech 1974). Flights were conducted twice daily in hopes of detecting Wolf-killed deer (Fuller 1989). When a Wolf pack was located, Wolves were counted and the area searched for ungulate carcasses. A kill was assumed to be caused by Wolves if there were bloodtrails indicating a successful chase and a disarticulated carcass (Hayes et al. 2000). At each kill site, the number and behavior of Wolves were recorded (Mech 1966). All Wolf-killed ungulates that could not be identified to species, gender and age (adult-calf) from the air were later ground inspected.

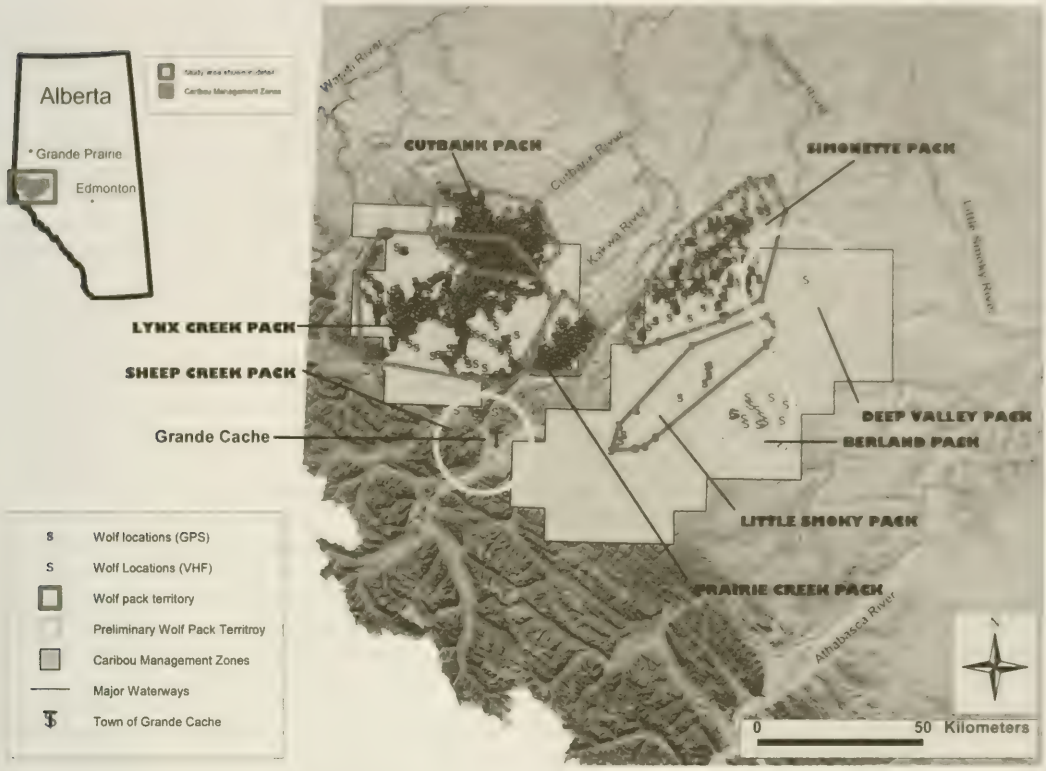

FIGURE 1. Distribution of eight Wolf packs on two Caribou winter ranges in west-central Alberta during 2000 and 2001.

TABLE 1. Sex ratio, age class and color phase of Wolves (n=31) captured in west-central Alberta during 22 January – 13 March, 2000 and 15–17 February, 2001.

Sex Ratio (n=31)	Age Class (n=31)	Color Phases (n=31)
14 Males	15 adults	19 black (61%)
17 Females	8 yearlings	8 gray (26%)
	8 pups	3 white (11%)
		1 blue (2%)

Results

Thirty-one Wolves were captured on two Caribou ranges: 18 captured in 2000 and 13 in 2001 (Table 1). Nine Wolves were aerially darted and 24 were netted (two recaptures). There were no capture-related Wolf mortalities during this study. A total of 16 GPS (14 Lotek and 2 Televilt) and 17 VHF radiocollars were deployed. There were seven known mortalities of radiocollared Wolves (23%) over fifteen months: two were shot and five died of natural or unknown causes. Colors phases of the radiocollared Wolves were 61% black, 26% gray, 11% white and 2% blue.

Eight Wolf packs were located on the two Caribou ranges (Tables 1 and 2; Figure 1). There were between 54 and 77 (mean = 66) Wolves on the Little Smoky and Red Rock/Prairie Creek Caribou ranges, equating

TABLE 2. Pack size of Wolves on the Red/Rock Prairie Creek (RPC) and Little Smoky (LSM) Caribou winter ranges in west-central Alberta in late winters of 2000 and 2001.

Wolf Pack	Estimated pack size	Caribou herd
Lynx Creek	12 – 18	RPC
Cutbank	7 – 8	RPC
Prairie Creek	5 – 6	RPC
Sheep Creek	6 – 7	RPC
Simonette	7 – 11	LSM
Little Smoky	7	LSM
Deep Valley	9	LSM
Berland	8 – 11	LSM
Total (Range)	54 – 77	
Total (Mean)	65.5	
Mean	8.2	

TABLE 3. Ungulate kills by Wolf packs in west-central Alberta in March 2000.

Wolf Pack	Days Monitored	Moose kills	Deer kills	Ungulate kills/day
Lynx Creek	9 (Mar 2-10)	2		1/ 4.5
Cutbank	14 (Mar 2-15)	3		1/ 4.7
Simonette	14 (Mar 2-15)	4	2	1/ 1.8

Note: Prairie Creek pack not entered as only one Elk kill was located.

to 8.2 Wolves/pack. Each Caribou range had between 30-39 Wolves with Wolf pack sizes ranging from 5-18 (Table 2). Twelve ungulate kills were recorded from four Wolf packs during 14 days of monitoring in March 2000 (Table 3). Ungulate kills consisted of seven cow and two calf Moose, two deer (unknown species) and one cow Elk. Wolves preyed predominately on Moose, averaging one Moose-kill every three to five days.

Discussion

We recorded a mean pack size of 8.2 Wolves/pack for eight Wolf packs on the RedRock/Prairie Creek and Little Smoky Caribou ranges. This is similar to the 8.7 Wolves/pack averaged over five other Alberta Wolf studies conducted between 1975 and 1985 (Gunson 1992) and marginally higher than the 6.8 Wolves per pack recorded in January 1995 in west-central Alberta during the Yellowstone-Idaho Wolf relocation (Kneteman 1995*). Pack size of Wolves in our study area varied considerably, ranging from 5 to 18 Wolves/pack. The larger Wolf packs (Lynx Creek n = 18; Simonette n = 11) preyed primarily on Moose, whereas the smallest pack (Prairie Creek n = 5) preyed predominately on deer, consistent with results from other nearby studies (Carbyn 1974; Weaver 1994). A confounding factor in estimating numbers of Wolf-killed ungulates in west-central Alberta is the difficulty of detecting Wolf-killed deer (Kuzyk 2002; Kuzyk et al. 2005), due to the small size and cryptic color of deer, and the short time required for Wolves to consume deer carcasses (Fuller 1989). All Wolf packs in this study were observed either hunting deer or at deer kills. During intensive monitoring in March 2000, the Prairie Creek pack was seen hunting deer, and was thought to have made deer kills, but those were never detected from the aircraft. This resulted in somewhat ambiguous information, as data indicate this pack killed only one Elk in nine days of monitoring. But further analysis of GPS data collected during the nine-day monitoring period suggested the Prairie Creek pack had made a minimum of three deer kills (Franke et al. 2006). The importance of deer to Wolves in this study area should not be underestimated. Kuzyk et al. (2005) found Wolves in this study area traveled 4.2 times less when near ungulate carcasses then when away from them, and suggested that Wolf packs preying primarily on deer, as opposed to Moose, may pose a greater predation risk to Caribou due to associated increase travel and encounter rates. Further research to quantify the importance of deer in this Wolf-ungulate system should be initiated such as measuring Wolf encounter rates with deer (Kunkel et al. 2004).

No Caribou kills were detected during this study, probably due to the low numbers of Caribou in the region (Smith 2004) and the short time it takes Wolves to consume a carcass (Hayes et al. 2000). Nevertheless, Caribou could not be the primary prey for Wolves in westcentral Alberta, as the numbers of Caribou could not support the numbers of Wolves we recorded. For example, there are fewer than 100 Caribou in the Little Smoky herd (Smith 2004), and four Wolf packs overlap their range, with each pack killing an estimated 40-85 ungulates each winter.

Humans may impact Wolf pack size when access to remote areas increases, and human-caused mortality to Wolves increases from shooting, trapping and road collisions (Mech 1995). Landscapes in west-central Alberta are being altered by resource extraction industries which have increased human access to previously remote areas. We recorded 23% mortality for radiocollared Wolves over fifteen months, similar to annual mortality rates (20-27%) found in other studies (Pletscher et al. 1997; Mech et al. 1998). This level of mortality is thought to be low and would not influence overall Wolf population size due to the high reproductive and dispersal rates of Wolves (Mech et al. 1998; Hayes et al. 2003). Forest harvesting can increase human access and change the amount and spatial distribution of habitats for Wolves and their prey. Wolf packs in our study area had a seven-fold difference in the amount of forest harvested within their territories (Kuzyk et al. 2004). The Cutbank pack (n = 7-8) had 36% of the forest in their territory harvested whereas the Lynx Creek (n = 12-18) pack had 7% harvested. The lowest level of forest removal corresponded with the largest pack size of 18 Wolves. In 2001, this pack contained 12 black and 6 gray Wolves and was observed traveling on a road in an open forest cutblock (Kuzyk 2001). This pack size exceeds the largest recorded from nearby studies: 12 Wolves in the Simonette River area (Bjorge and Gunson 1989) and 10 Wolves in northern Jasper National Park (Weaver 1994).

The color phase of a Wolf may influence its detection by humans (Mech et al. 1998) and subsequent mortality. Radiocollared Wolves in this study were predominantly black (61%), similar to those recorded in nearby Jasper National Park (53% black) (Dekker 1986). It is noteworthy that black Wolves may change to a lighter color possibly due to aging or physiological stress (Gipson et al. 2002). Black Wolves may be more easily detected by hunters, especially during winter and on fragmented landscapes. The two Wolves shot during our study were black, and of the seven total mortalities (2 shot, 5 natural or unknown), five Wolves were black (71%).

Lone and small groups of Wolves are also an important component of this population. During the two years of our monitoring, several Wolves dispersed from their natal territories, as individuals or in small groups (<3 Wolves), consistent with other research (Gese and Mech 1991). These lone Wolves, or small groups, could represent 10-30% of the Wolf population (Fuller 1989; Mech et al. 1998) and may be an important factor when assessing predation risk to Caribou. Such Wolves would be travelling great distances to establish new territories (Mech 1970), and may use human trails as travel routes

(Kuzyk and Kuzyk 2002), thereby increasing their chances of encountering Caribou. In addition, pairs of Wolves may have proportionately higher kill rates than larger packs (Hayes et al. 2000). Further, if Wolf packs generally avoid Caribou habitats due to a lack of Moose (James et al. 2004), dispersing Wolves may select these habitats to avoid being killed by resident pack Wolves defending their territories, a primary cause of natural Wolf mortality (Mech 1994). Conducting research on single or small groups of Wolves would be logistically difficult but resulting information could lead to important insights into Caribou predation risk from Wolves.

Documenting current pack size and prey relations of Wolves in our study area is an important step in understanding the potential implications of landscape change and resultant alteration of predator/prey systems for Caribou in the area. However, as pack size could theoretically remain constant while overall numbers increase, determining Wolf density is necessary. In combination with additional information on kill rates and prey availability, this would permit evaluation of the numerical and functional responses of Wolves in this system to landscape alteration, and provide a foundation for examining alternative management strategies aimed at long-term Caribou conservation.

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Bur Buttercup, *Ranunculus testiculatus*, New to Eastern Canada

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Bur Buttercup (*Ranunculus testiculatus*) is newly reported for eastern Canada based on two collections from campgrounds in southern Ontario. This vernal, annual, Eurasian weed is widespread in western North America and is expanding its range in the east; it should be expected elsewhere in eastern Canada. Bur Buttercup is known to be toxic to livestock.

Key Words: Bur Buttercup, *Ranunculus testiculatus*, Ranunculaceae, first records, weed, range expansion, campground, Ontario, eastern Canada.

On 17 April 2004, Blaney found an unusual buttercup growing on a campsite in Long Point Provincial Park, on the north shore of Lake Erie, Norfolk County, Ontario (42.58°North, 80.41°West). A few days later on 22 April 2004, Goodwin found the same species growing in a municipal campground in Cobourg, on the north shore of Lake Ontario, Northumberland County, Ontario (43.96°North, 78.16°West). This distinctive plant, called Bur Buttercup (*Ranunculus testiculatus* Crantz), has not previously been reported from Ontario (Morton and Venn 1990; Newmaster et al. 1998) or eastern Canada (Scoggan 1978; Gleason and Cronquist 1991; Whittemore 1997; Kartesz 1999).

Ranunculus testiculatus is a small scapose, somewhat tomentose, annual in the buttercup family (Ranunculaceae) which flowers early in the season. The leaves are entirely basal and are 1.5 to 4 cm long, ternate to biternate, with narrow linear divisions. The several leafless peduncles are 2 to 8 cm tall, and each bears a single, inconspicuous pale yellow flower (Figure 1). The fruiting heads are bur-like when dry and mature, giving the plant its common name, Bur Buttercup. Superficially the plant is very different in appearance from other buttercups and is often placed in a separate genus as *Ceratocephalus testiculatus* (Crantz) Roth by some authors (e.g., Cody 1988; Cusick 1989) or *Ceratocephala testiculata* (e.g., Tutin et al. 1993; Mitchell and Tucker 1997; Kartesz 1999). However, most recent North American floras now include it within *Ranunculus* (e.g., Gleason and Cronquist 1991; Whittemore 1997). A related species, *R. falcatus* L., has been reported from North America, but all reports are apparently based on misidentified material of *R. testiculatus* (Whittemore 1997). Common names used for *R. testiculatus* in North America include Bur Buttercup or Burbuttercup (e.g., Barkworth 1982; Pohl 1984; Cusick 1989; Gleason and Cronquist 1991; Swink and Wilhelm 1994), Hornseed Buttercup (e.g., Cody 1988; Douglas et al. 1999), Sage Buttercup (e.g., Mitchell and Tucker 1997), and Curve-seed-butterwort (e.g., Kartesz 1999).

The first North American report of *Ranunculus testiculatus* was from Utah in 1932, followed by discoveries in other western states soon after: Oregon in 1938, Washington in 1940, and Colorado in 1948 (Barkworth 1982). It continues to spread in western North America (Hitchcock and Cronquist 1973; Taylor 1983; Weber 1990; Whittemore 1997). In Canada, Bur Buttercup has been known from southern British Columbia for some time (Boivin 1966; Scoggan 1978), where it is infrequent in south-central and south-eastern parts of the province in dry disturbed clearings and sagebrush slopes in the steppe zone (Douglas et al. 1999). Cody (1988) reported the species new to Saskatchewan based on a collection from Assiniboia in 1987. Cody (1988) also mapped the Canadian distribution of *R. testiculatus*.

Cusick (1989) was the first to report Bur Buttercup in eastern North America, based on a 1977 collection from South Bass Island in western Lake Erie, and predicted it would be found elsewhere in the Great Lakes region. In New York State it was first collected in 1990 from the parking lot of a campground near Harriman in Orange County by D. J. DeLaubenfels (specimen in the New York State Museum, NYS A18183, personal communication C. Sheviak and T. Weldy). The first Chicago area collection was made in 1991 and with concerted searching it was found in 12 additional Chicago region counties in 1992 and 1993 (Swink and Wilhelm 1994). Other recent new state records are from Nebraska in 1970 (Macgrath and Weedon 1974), Iowa in 1984 (Pohl 1984), and Missouri in 1987 (Ladd and Schuette 1990). Bur Buttercup is considered a significant toxic weed of grazing lands in the western United States and has been responsible for the death of sheep (Olsen et al. 1982, 1983).

Several authors have noted the affinity of this species for campgrounds, particularly in eastern North Amer-

FIGURE 1. Bur Buttercup (*Ranunculus testiculatus*) plants. Long Point Provincial Park, Ontario, 6 May 2004. Photograph by Michael Oldham.

ica, for example the first reports from Iowa, Missouri, New York, Ohio, and the Chicago Region are all from campgrounds (Pohl 1984; Cusick 1989; Ladd and Schuette 1990; Swink and Wilhelm 1994; C. Sheviak personal communication). It seems likely that this species is dispersed by camping vehicles and associated equipment. The bur-like fruiting heads of the buttercup may readily attach to blankets and tents, and are thus carried to campsites that appear to provide ideal disturbed conditions. Other vernal, ephemeral Eurasian weedy species have found a niche in campgrounds and are presumed to have a similar dispersal mechanism, such as *Aira caryophyllea* (Silvery Hairgrass), *Aira praecox* (Early Hairgrass), *Apera interrupta* (Interrupted Windgrass), *Cerastium pumilum* (Curtis' Mouse-ear Chickweed), *Cerastium semidecandrum* (Small Mouse-ear Chickweed), *Erophila verna* (Spring Whitlow-grass), *Myosotis stricta* (Blue Scorpion-grass), *Poa bulbosa* (Bulbous Bluegrass), and *Veronica verna* (Spring Speedwell) (Crins et al. 1987; Oldham et al. 1995; Goltz 1996; Oldham and Zinck 1997). Both Ontario records are from campgrounds, a municipal campground in Cobourg, Northumberland County, and a provincial park campground at Long Point, Norfolk County. At both Ontario locations Bur Buttercup is well established but quite local. At Long Point Provincial Park at least 500 plants occur, but they were found on only a single campsite, possibly suggesting a relatively recent introduction. In addition, the Long Point peninsula has been relatively well botanized in the past (Reznicek and Catling 1989). At Cobourg, Bur Buttercup grew in open, disturbed ground on at least four campsites with *Erophila verna* and *Taraxacum officinale* (Common Dandelion), while at Long Point it was found in sandy soil beneath planted Scots Pine (*Pinus sylvestris*) with *Cerastium semidecandrum*, *Stellaria pallida* (Lesser Chickweed), *Poa annua* (Annual Bluegrass), *Myosotis stricta*, and *Taraxacum officinale* (Figure 2).

Collection data for the Ontario records are as follows:

ONTARIO, Norfolk County, Long Point Provincial Park, 42.58°North, 80.41°West, 6 May 2004, *M. J. Oldham 29983* (DAO, MICH, NHIC, TRTE, UWO).

Northumberland County, Cobourg Municipal Campground, 43.96°North, -78.16°West, 9 May 2004, *M. J. Oldham 29996* (DAO, MICH, NHIC, TRTE).

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Troy Weldy and Charles Sheviak provided information on Bur Buttercup in New York state. The comments of two anonymous reviewers were helpful in improving the manuscript.

FIGURE 2. Bur Buttercup (*Ranunculus testiculatus*) habitat at Long Point Provincial Park, Ontario, on 6 May 2004. Bur Buttercup plants appear as a light coloured area in front of the closest Scots Pine tree in the foreground. Photograph by Michael Oldham.

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Assessment of Effects of an Oil Pipeline on Caribou, *Rangifer tarandus granti*, Use of Riparian Habitats in Arctic Alaska, 2001–2003

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Elevated oil field pipelines may alter Caribou (*Rangifer tarandus granti*) movements and delay or prevent access to insect relief habitat. In an attempt to determine if the 40-km elevated Badami pipeline in northern Alaska changed Caribou use of riparian habitats at the three river crossings where the pipeline is buried, we quantified Caribou habitat use at all three crossings using time-lapse video cameras and aerial distribution surveys over three summers. We compared habitat use, behavior and duration of observations among pipeline and non-pipeline sites. We used a block experimental design with cameras at four sites at the three river crossings to evaluate differences in numbers of Caribou per day at pipeline and non-pipeline sites. At each crossing, four cameras were positioned, with one pair of cameras next to the pipeline (pipeline sites) and one pair of cameras 1.8-3.2 km upstream from the pipeline (non-pipeline sites); where cameras monitored the river bank and channel (river habitat) and the tundra within about 200 m of the river (tundra habitat). Peak numbers of Caribou per day occurred during early July 2003 and mid-July 2001 and 2002. Large numbers of Caribou recorded north of the pipeline during aerial surveys did not usually correspond with increased number per day recorded by cameras suggesting Caribou probably also crossed the pipeline outside of the riparian areas. We assessed local changes in riparian habitat use by comparing the numbers of Caribou per day in river and tundra habitats at pipeline and non-pipeline sites and found no difference. We assessed regional changes in riparian habitat use by comparing numbers of Caribou per day at pipeline sites and at non-pipeline sites and found no difference. Caribou groups spent an average of 1 minute longer at tundra pipeline sites and groups spent 30 seconds longer feeding and trotting at pipeline sites, but these differences were not significant.

Key Words: Caribou, *Rangifer tarandus granti*, aerial survey, insects, Badami pipeline riparian habitat, summer, time-lapse video, Alaska.

In northern Alaska, Caribou (*Rangifer tarandus granti*) regularly use insect relief habitats during the summer (Cameron and Whitten 1979; Murphy and Curatolo 1987; Walsh et al. 1992; Pollard et al. 1996a, b; Young and McCabe 1998). This frequently involves north-south movements from inland feeding habitats to coastal insect relief habitats (Cameron and Whitten 1979; Pollard et al. 1996b). Oil transport pipelines traverse open tundra and riparian corridors, often in an east-west direction, so there is the potential for obstruction of movements to and from insect relief habitats (National Research Council 2003). Previous work has shown that pipelines associated with roads can have an impact Caribou movements (Murphy and Lawhead 2000); however, impacts from pipelines not associated with roads and elevated ≥ 1.5 m above the tundra, a height designed as a mitigation to allow Caribou passage (Cronin et al. 1994*), have not been documented.

One such pipeline on Alaska's north slope runs 40 km from the Badami oil production site to the oil fields at Prudhoe Bay. Most of the Badami pipeline is elevated about 1.5 m above the tundra, but it is buried underneath the three rivers it crosses (Figure 1 and 2). Caribou are common in this area during the summer, and aerial surveys document animals on the north and south sides of the pipeline, indicating that they cross the pipeline (Jensen and Noel 2002*; Jensen et al. 2003*; Noel and Cunningham 2003*). However, the elevated sections of this pipeline could alter Caribou movement and delay access to coastal habitats (National Research Council 2003). If this occurs, Caribou should be more likely to cross the pipeline in the riparian zones (including the river and adjacent tundra) where the pipeline is buried. We recorded Caribou by using time-lapse video and aerial distribution surveys over three years to assess whether Caribou use of riparian habitats was influenced by the pipeline.

Methods

Study Area

A 40-km elevated pipeline extends from the Badami facility (70°9'2.71"N, 147°1'25.93"W) across undeveloped terrain to the Endicott pipeline near the Prudhoe Bay oil field (70°15'18.25"N, 148°1'32.75"W, Figure

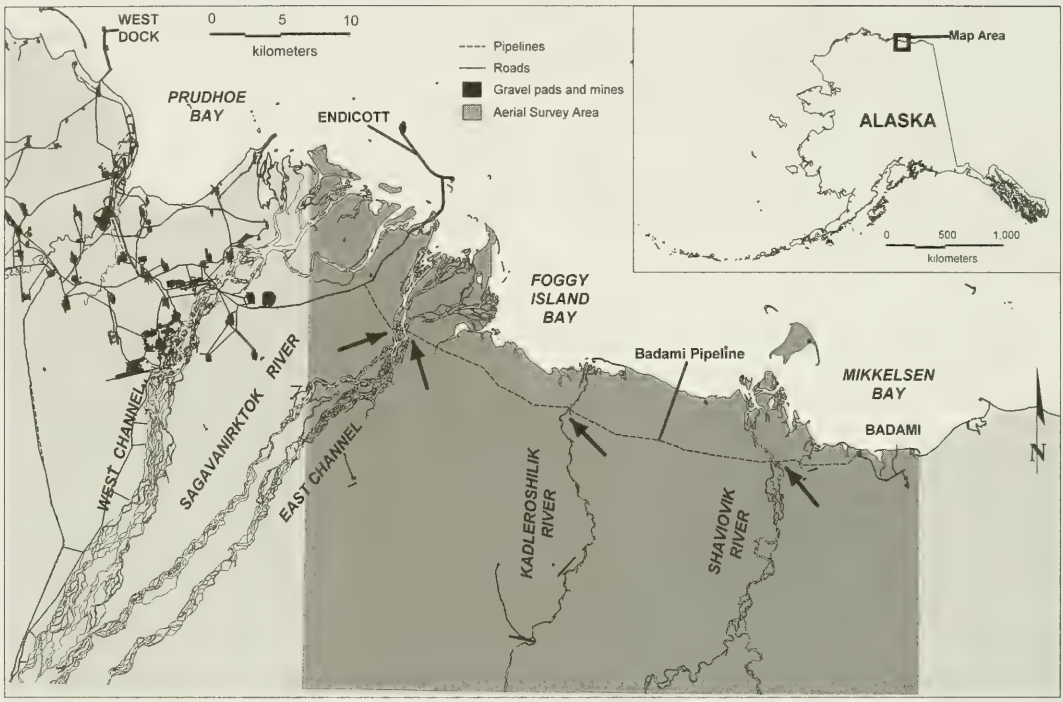

FIGURE 1. Study area, North Slope, Alaska. Arrows indicate study sites.

1). The Badami pipeline is elevated ≥ 1.5 m above the tundra surface for > 99% of its length. This pipeline is buried beneath the East Channel of the Sagavanirktok, Shaviovik, and Kadleroshilik rivers. At the Sagavanirktok and Shaviovik rivers, the pipeline is buried for about 1000 m; at the Kadleroshilik River the pipeline is buried for about 400 m. The Sagavanirktok River crossing is split into two channels by a large vegetated river bar; requiring two sites to be monitored. The tundra between these river channels is a gently rolling thaw-lake plain landscape with elevation rises of 6 to 8 m (Walker and Acevedo 1987).

Time-Lapse Videography

We used time-lapse video camera assemblies to monitor Caribou movements between 19 June and 26 August in 2001, 2002, and 2003. Each camera assembly consisted of a GYYR™ TLC1800-DC time-lapse videocassette recorder and a Panasonic™ WV-CL 322 color CCTV digital camera equipped with a Computar™ APC auto-iris 8.5 mm semi wide-angle lens (Pollard and Noel 1994*; Noel et al. 1998). Each assembly was powered by four 12-volt, 80-amp sealed lead acid batteries, charged by four Solarex™ SX-56 photovoltaic panels. The video recorder, camera, and batteries were housed in insulated aluminum casings to protect them from weather and animals. The time-lapse video recorders were set to record at 3–4 second intervals. Markers were placed 100 m from each camera to assist in determining visibility and to standardize the area sampled. Cameras had a 72° view angle resulting in a 7260-m^2 field of view out to 100 m (i.e., the sampling area). Videotapes were changed at 10–13 day intervals.

The cameras were arranged as follows at four river crossings (Figure 1): (1) the east side of the buried East Channel Sagavanirktok crossing (E Sag), (2) the west side of the buried East Channel Sagavanirktok crossing (W Sag), (3) the east side of the Shaviovik River crossing (Shav), and (4) the east side of the Kadleroshilik River crossing (Kad). At each crossing, four cameras were positioned, with one pair of cameras next to the pipeline (pipeline sites) and one pair of cameras 1.8-3.2 km upstream from the pipeline (non-pipeline sites) (Figure 2). One of each pair of cameras monitored the river bank and channel (river habitat), while the other monitored the tundra within about 200 m of the river (tundra habitat).

Non-pipeline sites with river channel width and configuration and tundra habitats similar to those of the corresponding pipeline sites were selected to reduce variability. This arrangement allowed us to collect Caribou data in four settings at each river crossing (Figure 2): (1) along the pipeline corridor where the pipeline was buried under the river (buried pipeline site/river habitat), (2) along the pipeline corridor where the pipeline was elevated above the tundra (elevated pipeline site/tundra habitat), (3) 1.8–3.2 km upstream from the

pipeline at the river's edge (non-pipeline site/river habitat), and (4) upstream from the pipeline on the tundra (non-pipeline site/tundra habitat).

Videotapes were viewed and the number of Caribou groups seen each day by each of the cameras was recorded. Caribou groups were defined by lapses of 15-30 seconds of tape with no Caribou observations. For each group observed within 100 m of the camera, data for the number of individuals, sex/age category, predominant behavior, and direction of movement were recorded. Caribou group behaviors included: feeding, resting (laying), standing, walking, trotting, running, and swimming.

Aerial Surveys

Eleven systematic aerial strip-transect surveys were completed from a Cessna 206 fixed-wing aircraft (Caughley 1977) to document the number of Caribou within a 1043 km^2 area surrounding the Badami pipeline between 25 June and 1 August 2001-2003 (Figure 1) (Jensen and Noel 2002*; Jensen et al. 2003*; Noel and Cunningham 2003*). Transect centerlines were spaced at 1.6-km intervals, oriented north-south, and centered on township and section lines from 1 : 63360 scale U.S. Geological Survey (USGS) topographic maps. Transects were flown at 90 m altitude and 130–180 km/h. Two observers, each searching an 800-m wide area on their side of the transect centerline, provided 100% coverage of the survey area. Aircraft wing struts were marked to enable visual control of transect strip width and estimation of distance between Caribou groups and the survey aircraft (Pennycuick and Western 1972). Global positioning system (GPS) receivers were used for navigating the aircraft along transects and for estimating the location of the aircraft when animals were observed. The locations of animals were recorded using a GPS receiver linked to a notebook computer. For each sighting, species, group size, group composition, and perpendicular distance from the aircraft were recorded. Coordinates of animal sightings were later calculated using the visual estimates of distance from the aircraft to offset the GPS aircraft positions. Geographic Information System (GIS) software was used to complete geographic summaries.

Weather Data

An automated weather station was established near the East Channel Sagavanirktok River. Temperature (T100 probe with radiation shield) and wind (Gill 3-cup anemometer, Gill low threshold vane) sensors transmitted readings at 5-min intervals to a data recorder which averaged and stored values as mean hourly wind speed and mean hourly air temperature data (Dryden R2® data logger, Anchorage, Alaska).

Data Analysis

The cameras were arranged to create a complete block experimental design (Steel and Torrie 1980). Each river location (E Sag, W Sag, Kad, or Shav) was a complete block containing all four settings: buried pipeline site/river habitat, elevated pipeline site/tundra habitat, non-pipeline site/river habitat, and non-pipeline site/tundra habitat, resulting in two cameras at the pipeline site and two cameras at the non-pipeline site (Figure 2). The potential for the pipeline to change Caribou habitat use was assessed by comparing mean numbers of Caribou per day (averaged for each year) among the four settings, and by evaluating the direction, duration and behavior of Caribou observed by the time-lapse cameras. We summarize the aerial survey data to compare the numbers of Caribou recorded using time-lapse cameras to the numbers of Caribou within the survey area, north of the pipeline and within riparian habitats. Riparian habitats were defined as a 200 m area surrounding the Sagavanirktok, Kadleroshilik, and Shaviovik rivers (Figure 1). Observation duration, direction of movement, behavior, temperature, and

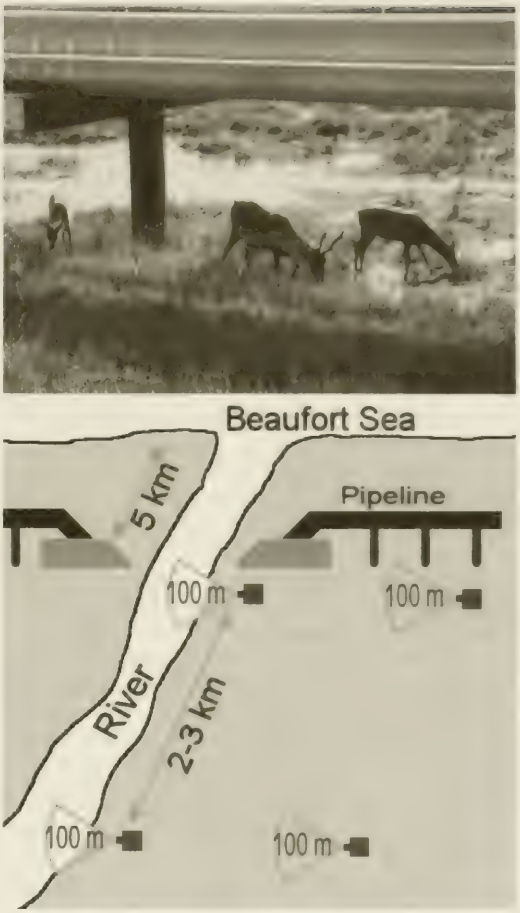

FIGURE 2. Top: An elevated pipeline on Alaska's North Slope. Bottom: Schematic showing the positions of four cameras relative to a river and the Badami Pipeline. As shown, the pipeline is buried at river crossings. (Drawing by Daniel King not to scale.)

wind speed were compared among habitats and with and without the pipeline using a general linear model and analysis of variance (ANOVA).

The block design allowed for the evaluation of local (within the riparian zone) and regional changes in Caribou use of riparian habitats. At a local scale, if Caribou changed habitat use due to the elevated pipeline within the riparian zone (i.e., within 200 m of the river bank), we would expect more Caribou to use river habitat at the pipeline sites compared to river habitat at the non-pipeline sites, as Caribou would avoid the elevated portion of the pipeline by crossing at the river where the pipeline was buried. At a regional scale, if Caribou moved toward the riparian corridors along the pipeline corridor, we would expect to see more Caribou at the pipeline sites (both river and tundra habitats) than at the comparable non-pipeline sites (both river and tundra habitats), as blockage of direct north-south movements by the elevated pipeline would lead to east-west Caribou movements along its length.

We used complete block ANOVA to assess local and regional changes in Caribou use of riparian habitats. Because of the lack of independence between counts of Caribou on consecutive days, we averaged the number of Caribou per day across each year, and used this mean as the response variable, giving an overall sample size of n=47. The ANOVA model was:

Caribou per day = Constant + Location + Year + Pipeline + Habitat + (Pipeline × Habitat),

where:

Constant = overall mean Caribou per day

Location = a block for each river crossing (W Sag, E Sag, Kad, or Shav),

Year = each year of the study (2001, 2002, and 2003)

Pipeline = pipeline site or non-pipeline site, and

Habitat = river or tundra.

All statistical analyses were conducted with SYSTAT® Version 10.2 (SYSTAT® Software Inc., Richmond, California).

Results and Discussion

Peak numbers of Caribou per day were recorded during early July in 2003 and mid July in 2001 and 2002 (Figure 3). Peaks in mean daily temperature coincided with increased numbers of Caribou per day recorded by cameras during late June and early July, but trends were not consistent. During the 11 aerial surveys between 25 June and 1 August 2001–2003, 36% of the Caribou were distributed north of the pipeline within 13% of survey area and 17% of the Caribou were within riparian habitats representing 9% of survey area (Table 1). Generally, when few Caribou were recorded within the survey area, no Caribou were recorded by the time-lapse cameras (Table 1, Figure 3).

The sex-age distribution of Caribou occuring within the survey area was dominated by adult cows (61%–70%) based on the aerial survey data (Table 1). These sex-age distributions are estimates and likely underrepresent calves based on the results of fall composition surveys for this herd of 28% bulls, 42% cows and 30% calves (Lenart 2003*). Sex-age distributions based on time-lapsed video were more similar to fall composition results (Lenart 2003*), but nearly half of the individuals were unclassified (Table 1).

Mean annual Caribou per day by camera ranged from 0.3–20.4 across habitats, pipeline configurations, river locations, and years (Table 2). Least squares means from the ANOVA show that Caribou were more abundant in tundra habitats (mean = 8.9 Caribou per day) than in river habitats (mean = 3.3 Caribou per day) (Table 3). This difference between habitats was the only significant factor ($P = 0.02$, Table 4).

If local habitat use changed because of the presence of the elevated pipeline, more Caribou would have been seen in river habitat than in tundra habitat at the pipeline sites. This local effect was reflected in the ANOVA Habitat × Pipeline interaction term, which was not significant ($P = 0.64$, Table 4). The difference between mean Caribou per day in tundra and river habitats (7.6 and 3.2 Caribou per day, respectively) was smaller for pipeline sites than for non-pipeline sites (10.4 and 3.5 Caribou per day, respectively).

Because we detected no effect on numbers of Caribou per day, we evaluated the duration that Caribou were recorded at pipeline and non-pipeline sites on the tundra (Table 5). Blockage of northward or southward movements across the pipeline corridor could result in delays at pipeline sites, which would be reflected in duration and behavior at these sites. Groups moving north appeared to spend an average of one minute longer at pipeline sites in tundra habitats, while groups moving south spent about two minutes longer at non-pipeline sites (Table 5). A general linear model was used to test whether the presence of the pipeline affected observation duration for Caribou moving northward potentially seeking refuge from insects. Neither the presence of the pipeline nor the explanatory variables habitat (river versus tundra), temperature, and wind speed (atmospheric conditions may have an effect on the severity of insect harrassment) had statistically significant ($P = 0.05$) effects on the observation duration for Caribou moving northward. Duration of group behaviors indicated that Caribou spent about 30 seconds longer feeding and trotting on the tundra at pipeline sites than non-pipeline sites (Table 6). Separate ANOVAs were applied to the duration of feeding, trotting, and walking activities in different habitats (river and tundra) and in the presence or absence of the pipeline. For trotting and walking, neither habitat nor pipeline or their interaction were significant explanatory variables ($P > 0.2$). For feeding Caribou, the duration within tundra (mean = 00:01:09) was significantly longer than within river (mean = 00:06:35, $P = 0.002$).

If the pipeline caused regional changes in Caribou riparian habitat use, we would expect to see more Caribou at the pipeline sites than at the non-pipeline sites. However, the difference between mean Caribou per day at the pipeline and non-pipeline sites (5.4 and 6.8 Caribou per day, respectively, Table 3) was not signifi-

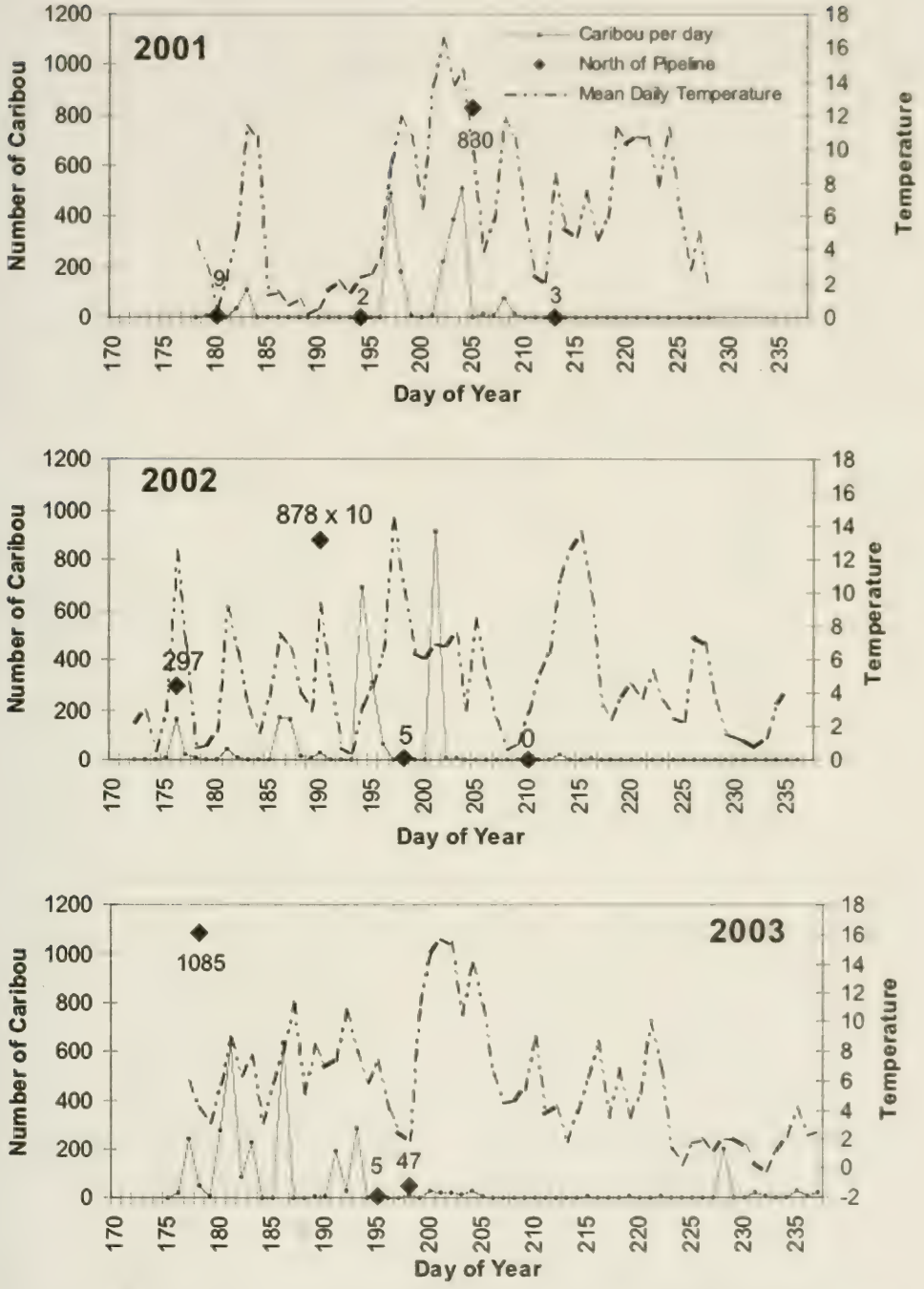

FIGURE 3. Comparison of numbers of Caribou recorded per day for all time-lapse cameras, numbers of Caribou recorded in riparian habitats north of the Badami pipeline corridor during aerial surveys (Figure 1), and mean daily temperature (°C), 19 June (day 170) 26 August (day 238) 2001–2003, North Slope, Alaska.

TABLE 1. Summary of Caribou sex-age classes, numbers, and distribution within the aerial survey area and observed in riparian areas at pipeline and non-pipeline sites using time-lapse video 19 June–26 August 2001–2003, North Slope, Alaska. For bulls, cows, and calves % is per cent of classified. Unclassified % is per cent of total.

	Bulls		Cows		Calves		Unclassified		Total Caribou	Total Groups	Percent of Total
Aerial Surveys											
Survey Area (1043 km^2)	2846	12%	16001	65%	5775	23%	5798	19%	30420	775	
North of Pipeline (136 km^2)	1479	14%	7492	70%	1807	17%	287	3%	11065	134	36%
Riparian Zone (98 km^2)	811	21%	2392	61%	722	18%	1222	24%	5147	111	17%
Time-Lapse Video											
All Sites (1293 days)	1352	36%	1352	36%	1005	27%	4165	53%	7874	635	
Pipeline Sites (660 days)	664	37%	659	37%	457	26%	1816	51%	3596	352	46%
Non-Pipeline Sites (633 days)	688	36%	693	36%	548	28%	2349	55%	4278	283	54%

TABLE 2. Total Caribou, days of camera operation, and mean Caribou per day by camera with standard deviation (SD) for all three years pooled, 19 June–26 August 2001–2003, North Slope, Alaska.

Camera Site	Habitat	Pipeline	Total Caribou	Days of camera operation	Caribou per day (SD)
W Sag 1	Tundra	Elevated	562	89.88	5.8 (35.32)
W Sag 2	River	Buried	22	87.62	0.2 (1.47)
W Sag 3	Tundra	Non-pipeline	488	86.88	5.1 (25.70)
W Sag 4	River	Non-pipeline	8	88.67	0.1 (0.82)
E Sag 1	River	Buried	243	78.60	2.8 (14.56)
E Sag 2	Tundra	Elevated	1122	77.88	12.9 (63.03)
E Sag 3	River	Non-pipeline	320	81.23	3.6 (19.21)
E Sag 4	Tundra	Non-pipeline	596	77.78	6.7 (29.63)
Kad 1	River	Buried	151	79.67	1.6 (7.19)
Kad 2	Tundra	Elevated	234	88.42	2.5 (13.54)
Kad 3	River	Non-pipeline	591	84.98	6.5 (36.29)
Kad 4	Tundra	Non-pipeline	1222	59.81	19.1 (77.81)
Shav 1	River	Buried	629	80.20	7.1 (27.53)
Shav 2	Tundra	Elevated	633	78.00	7.3 (27.52)
Shav 3	River	Non-pipeline	225	76.32	2.6 (14.29)
Shav 4	Tundra	Non-pipeline	828	76.93	9.5 (48.67)
Grand Total			7874	1292.87	

TABLE 3. Caribou per day by pipeline and habitat with sites pooled (buried pipeline site/river habitat, elevated pipeline site/tundra habitat, non-pipeline site/river habitat, non-pipeline site/tundra habitat), 19 June–26 August 2001–2003, North Slope, Alaska.

	Habitat		
Pipeline	River	Tundra	Total
Pipeline	3.2	7.6	5.5
Non-pipeline	3.5	10.4	6.8
Total	3.3	8.9	6.1

cant ($P = 0.57$, Table 4). Peaks in the number of Caribou north of the pipeline in 2002 and 2003 did not coincide with large numbers of Caribou recorded at cameras, suggesting that Caribou crossed the pipeline outside of riparian areas (Figure 3).

The results of this study support the conclusion that pipelines elevated ≥1.5 m above the tundra did not cause changes in Caribou riparian habitat use at buried river crossings or delay north-south movements to and from coastal insect relief habitats (Cronin et al. 1994*, Murphy and Lawhead 2000).

TABLE 4. Results of ANOVA for Caribou per day along three rivers crossed by the Badami pipeline during 19 June–26 August 2001–2003, North Slope, Alaska.

Source	Sum-of-Squares	df	Mean-Square	*F*-ratio	*P*
Pipeline (Present, Absent)	22.08	1.00	22.08	0.33	0.57
Habitat (River, Tundra)	415.86	1.00	415.86	6.29	0.02
Location (i.e., Block) (E Sag, W Sag, Kad, Shav)	170.90	3.00	56.97	0.86	0.47
Year (2001, 2002, 2003)	29.50	2.00	14.75	0.22	0.80
Interaction (Pipeline × Habitat)	14.40	1.00	14.40	0.22	0.64
Error	2512.10	38.00	66.11		

TABLE 5. Total duration and mean duration for time-lapse video Caribou observations mean temperature (°C) and mean wind speed (meters per second) within tundra and river habitats at pipeline and non-pipeline sites for groups moving north and south during 19 June–26 August 2001–2003, North Slope, Alaska. Mean values presented with standard deviations (SD), number of observations (*n*).

		Direction											
		North						South					
		n	Total	Mean	SD	Temp (SD)	Wind (SD)	*n*	Total	Mean	SD	Temp	Wind
Pipeline	River	19	0:24:22	0:01:17	0:02:04	11.8 (4.5)	3.0 (1.4)	32	0:52:37	0:01:39	0:01:18	8.2 (4.5)	4.1 (1.9)
	Tundra	45	2:35:13	0:03:27	0:05:09	8.8 (4.9)	2.9 (1.8)	101	3:53:25	0:02:19	0:03:03	7.8 (4.6)	3.0 (1.6)
	Total	64	2:59:35	0:02:48	0:04:33	9.6 (5.0)	3.0 (1.7)	133	4:46:02	0:02:09	0:02:44	7.9 (4.5)	3.3 (1.7)
Non-pipeline	River	34	0:45:45	0:01:21	0:01:39	9.4 (3.9)	2.5 (1.3)	21	0:37:56	0:01:48	0:01:52	8.3 (4.5)	2.6 (1.2)
	Tundra	59	2:09:34	0:02:12	0:03:02	8.0 (3.9)	2.7 (1.6)	65	4:53:49	0:04:31	0:06:58	6.3 (3.6)	3.2 (1.9)
	Total	93	2:55:19	0:01:53	0:02:38	8.5 (3.9)	2.6 (1.5)	86	5:31:45	0:03:51	0:06:13	6.8 (3.9)	3.1 (1.8)
All	Total	157	5:54:54	0:02:16	0:03:33	9.0 (4.4)	2.8 (1.6)	219	10:17:47	0:02:49	0:04:31	7.5 (4.3)	3.2 (1.7)

TABLE 6. Total duration and mean durations for time-lapse video Caribou observations within tundra and river habitats at pipeline and non-pipeline sites for groups feeding, walking or trotting during 19 June–26 August 2001–2003, North Slope, Alaska. Mean values presented with standard deviations (SD), number of observations (*n*).

		Feeding				Walking				Trotting			
		n	Total	Mean	SD	*n*	Total	Mean	SD	*n*	Total	Mean	SD
Pipeline	River	12	0:18:27	0:01:32	0:01:02	61	4:45:46	0:04:41	0:15:23	25	0:35:36	0:01:25	0:01:56
	Tundra	80	9:23:17	0:07:02	0:07:13	117	3:53:04	0:02:00	0:02:30	31	0:37:11	0:01:12	0:01:51
	Total	92	9:41:44	0:06:19	0:06:59	178	8:38:50	0:02:55	0:09:16	56	1:12:47	0:01:18	0:01:52
Non-pipeline	River	6	0:10:00	0:01:40	0:01:31	38	1:06:29	0:01:45	0:01:35	23	0:35:58	0:01:34	0:01:46
	Tundra	54	5:58:02	0:06:38	0:06:43	84	3:05:50	0:02:13	0:03:04	42	0:33:42	0:00:48	0:00:49
	Total	60	6:08:02	0:06:08	0:06:33	122	4:12:19	0:02:04	0:02:42	65	1:09:40	0:01:04	0:01:16
All	Total	152	15:49:46	0:06:15	0:06:48	300	12:51:09	0:02:34	0:07:21	121	2:22:27	0:01:11	0:01:34

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First Records of the Southern Red-backed Vole, *Myodes gapperi*, in the Yukon

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Twenty Southern Red-backed Voles, *Myodes gapperi*, were collected in July 2004 in the LaBiche River valley of southeastern Yukon. Specimens were identified using morphological characteristics and analysis of cytochrome *b* gene sequences. These are the first records of this species in the Yukon. No Northern Red-backed Voles, *M. rutilus*, were collected and it is not known whether the two species are sympatric or parapatric in the Yukon. Further survey work is needed in southeastern Yukon to better delineate the extent of the northwestern range of this species and the extent, if any, of introgression with *M. rutilus*.

Key Words: Southern Red-backed Vole, *Myodes gapperi*, distribution, Yukon.

The Southern Red-backed Vole (*Myodes* [formerly *Clethrionomys* see Musser et al. 2005] *gapperi*) is broadly distributed across the boreal, montane, Pacific coastal, and other conifer-dominated forests of North America (Banfield 1974; Merritt 1981; Batzli 1999). Youngman (1975) did not report *M. gapperi* from the Yukon, in part, because he was of the opinion that *M. gapperi* and the Northern Red-backed Vole (*M. rutilus*) were conspecific. Cook et al. (2004), however, provided molecular data that reinforced the separate status of *M. gapperi* and *M. rutilus*. North American species of *Myodes*, including *M. gapperi* and *M. rutilus*, are cryptic and field identification is highly problematic where congeners come into contact (Merritt 1981; McPhee 1984; Runck 2001, Nagorsen 2002, 2005; Cook et al. 2004). Therefore, we considered that *M. gapperi* may have been overlooked in the Yukon due to the difficulty in distinguishing specimens from *M. rutilus* in the field, and a general paucity of mammalian diversity surveys in most of the Yukon. Based on the distribution of *M. gapperi* in adjacent northeastern British Columbia and southwestern Northwest Territories (Banfield 1974; Nagorsen 2005) we suspected the greatest likelihood of finding the species in the Yukon was in the Liard River Watershed. In summer 2004, we undertook a brief field survey of mammalian diversity in the boreal forest of southeastern Yukon, partially with an aim to procuring specimens of *M. gapperi*. Here, we provide the first records of the Southern Red-backed Vole in the Yukon.

Methods

On 28 July – 2 August 2004, we used pitfall and snap traps to collect shrews and rodents in the LaBiche River Valley (60.126°N, 124.064°W) of southeastern Yukon. Seven habitats were sampled: wet meadows and shrub thickets adjacent to Beaver (*Castor canadensis*) ponds; xeric grassy meadows; riparian old-growth White Spruce (*Picea glauca*) forest; lowland Black Spruce (*Picea mariana*) forest; subalpine old-growth Spruce-fir (*Abies lasiocarpa*) forest; second-growth mixedwood forest; and regenerating clearcut forest. All habitats were sampled with snap traps. We established 14 variable length traplines (ca. 100 m – 250 m) in each of the seven habitat types. Trap stations were set 10 m apart on the traplines. One Museum Special snap trap and one Victor snap trap (Woodstream, Lititz, Pennsylvannia) were set at each trapping station. Traps were baited with oats and peanut butter, run for 2-3 days and checked each morning. In addition to the snap traps, we established three traplines of metal conical pitfall traps in the wet meadow habitats, primarly to capture soricids. Pitfall traps were 25 cm in height and 15 cm in diameter at the top. Pitfall traps were also arranged in traplines with one trapline in each of the wet meadows sampled. Traps were spaced about 10 m apart, with 15 or 20 traps per trapline, and installed flush with the ground surface. Pitfall traps were not baited and they were left open for 3-5 days. Each morning we checked the traps and processed the captures.

Captures were tentatively identified to species, measured, aged, weighed, sexed, and examined for reproductive condition. Whole carcasses were frozen on site. Species were tentatively identified in the field using morphological, pelage, and dental characteristics, following Nagorsen (2002) and van Zyll de Jong (1983). Because of the difficulty in distinguishing *M. rutilus* from *M. gapperi* in the field, we undertook subsequent laboratory investigations at Idaho State University (Pocatello, Idaho) to confirm our field identifications. All skulls were examined for fusion of the post-palatal bridge (Merritt 1981; Nagorsen 2002) and the first 600 base pairs (bp) of mitochondrial cytochrome *b* gene were examined to confirm species identification. Restriction enzyme screening and sequencing of cytochrome *b* followed established protocols for *Myodes* (Runck and Cook 2005). All individuals underwent restriction enzyme digestion using the restriction enzyme ALU I to determine the presence of the restriction site AGCT which is found in the 600 bp fragment of the cytochrome *b* gene in *M. rutilus* but not *M. gapperi* (Runck 2001). Five random individuals were sequenced for the first 600 bp of the cytochrome *b* gene and were used in a phylogenetic reconstruction using published sequences of *Myodes* (Cook et al. 2004; Runck and Cook 2005), representing *M. gapperi* ($n = 10$), *M. rutilus* ($n = 2$), *M. californicus* ($n = 1$), *M. glareolus* ($n = 1$), and *M. rufocanus* ($n = 1$). Sequences for specimens not collected in LaBiche (Figure 1) were taken from GenBank. Phylogeographic reconstruction was conducted using neighbor-joining framework in PAUP b10 (Swofford 2002) using the Tamura and Nei (1993) model of sequence evolution as determined through Modeltest (Posada and Crandall 2000).

Results and Discussion

We captured 20 *Myodes* during sampling. Field identification, based on morphological (tail and pelage) characteristics, suggested that all captures were of *M. gapperi*. Further, 15 of the 20 specimens had complete post-palatal bridges, which is a primary diagnostic characteristic of *M. gapperi* (Merritt 1981; Nagorsen 2002). Two specimens had incomplete post-palatal bridges and the bridges of a further three were broken by the traps and not usable as a diagnostic character. Genetic analyses using restriction enzyme screening and sequencing of cytochrome *b* gene confirmed that all 20 specimens of *Myodes* collected in the LaBiche River Valley were *M. gapperi* (Figure 1).

The Southern Red-backed Vole is now added to the list of mammals in the Yukon. This is the first additional rodent found in the Yukon since Youngman (1975). These 20 specimens were deposited at the Museum of Southwestern Biology at the University of New Mexico (Albuquerque, New Mexico).

Capture rates were 0.28 per 100 trap nights (TN) and 1.32 per 100 TN in pitfall and snap traps, respectively. Captures of *M. gapperi* represented the range of sex and age classes (5 adult females, 7 adult males, 5 juvenile females, and 3 juvenile males), confirming that a breeding population was present. *M. gapperi* were taken in all of the habitats sampled. Species caught in association with *M. gapperi* in the LaBiche River Valley included: Meadow Voles (*Microtus pennsylvanicus*, $n = 14$), Deer Mice (*Peromyscus maniculatus*, $n = 13$), Meadow Jumping Mice (*Zapus hudsonius*, $n = 10$), Eastern Heather Vole (*Phenacomys ungava*, $n = 1$), Masked Shrew (*Sorex cinereus*, $n = 1$), Pygmy Shrew (*Sorex hoyi*, $n = 1$), and Dusky Shrews (*Sorex monticolus*, $n = 2$).

We do not know the extent of the range of the Southern Red-backed Vole in the Yukon. They have been collected, however, near Fort Liard, Northwest Territories (S. Carrière, unpublished data; Runck and Cook 2005). Specimens from near Watson Lake, Yukon (ca. 270 km W of the present study; $n = 43$), were also analyzed in the lab using skull and genetic characters and they were determined to be *M. rutilus* (T. S. Jung and A. M. Runck, unpublished data), suggesting that *M. gapperi* may not be widely distributed in southern Yukon. Perhaps *M. gapperi* is restricted in the Yukon to the extension of the Boreal Plain ecoregion in the extreme southeast. Further surveys from nearby river valleys, and subsequent DNA analysis, are needed to better document the ranges and contact zone of *M. gapperi* and *M. rutilus* in southeastern Yukon and adjacent British Columbia and Northwest Territories. Our discovery of *M. gapperi* in extreme southeastern Yukon, along with that of the Yukon's only records of Northern Long-eared Bats (*Myotis septentrionalis*; Jung et al. 2005) and other taxa (e.g., some species of neotropical migrant passerines: Eckert et al. 1997), suggests that this ecoregion may be a zoogeographically unique part of the Yukon.

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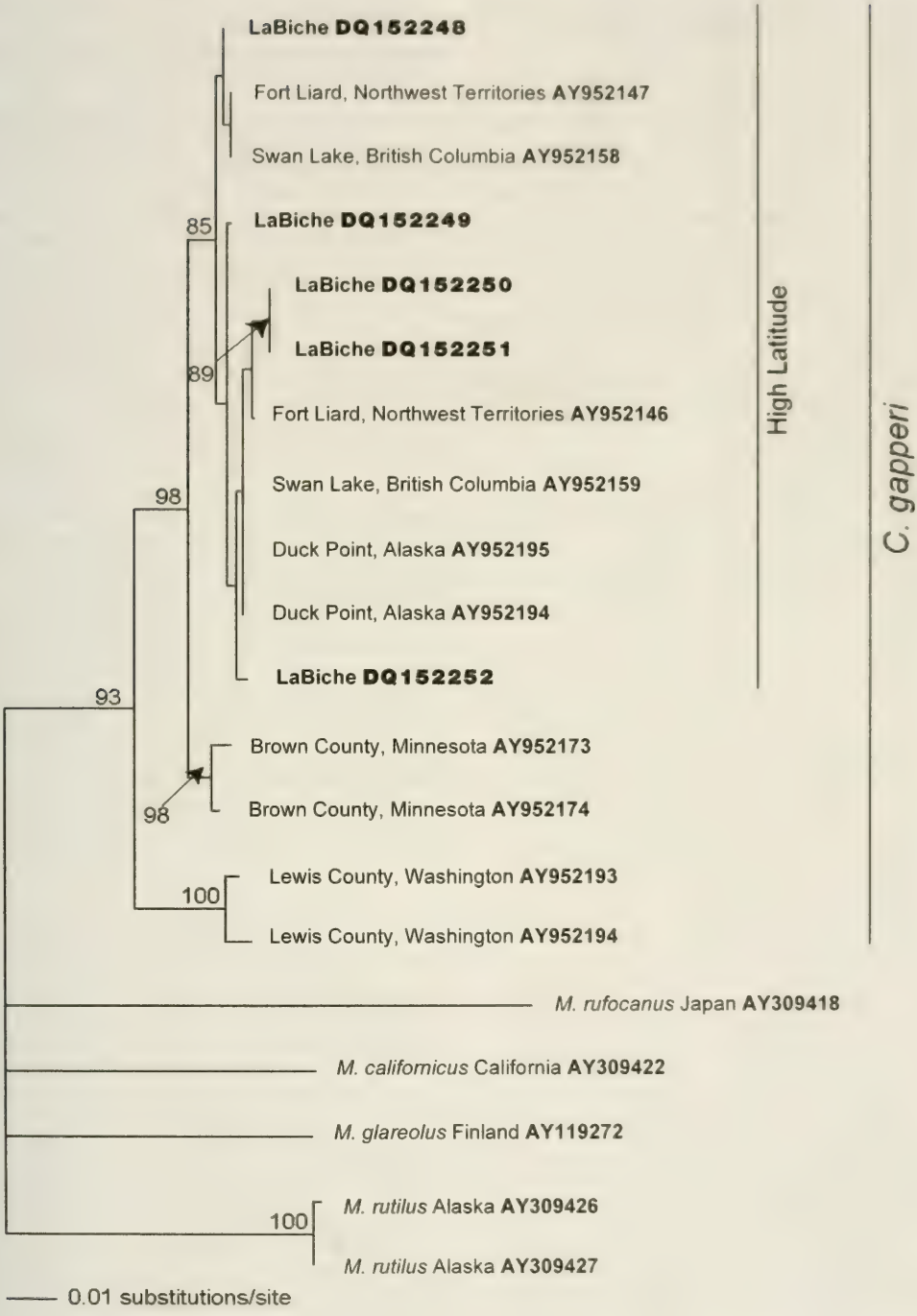

FIGURE 1. Placement of five specimens of *Myodes gapperi* (LaBiche DQ152248-DQ152252) captured in the LaBiche River Valley, Yukon, based a neighbor-joining analysis of cytochrome *b* gene sequences (600 bp) of these specimens and compared to sequences of other *Myodes*. GenBank accession numbers for sequences used are included for each specimen. Numbers above the branches represent bootstrap support values for those nodes.

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A Conservation Evaluation of Smooth Goosefoot, *Chenopodium subglabrum* (Chenopodiaceae), in Canada

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Smooth Goosefoot (*Chenopodium subglabrum*) is restricted to North America and reaches its northern distribution limit in Alberta, Saskatchewan and Manitoba. The habitat of *Chenopodium subglabrum* contains some element of active sand. It is commonly found on the stabilizing edges of active dunes as well as dune blowouts, and occasionally on bare or recently disturbed sand plains. *Chenopodium subglabrum* is a sexually reproducing annual species with seeds that may remain in the seed bank for several years, waiting for the conditions it favours for germination. Germination of this species is erratic, possibly in response to moisture, making the overall population trend difficult to determine. The estimated population in Canada is likely between 5000 and 10000 individuals. There has been considerable loss of habitat as dunes become vegetated. The processes of dune stabilization and fire control threaten survival of this species.

Key Words: *Chenopodium subglabrum*, Smooth Goosefoot, distribution, population size, rare, Alberta, Saskatchewan, Manitoba.

Chenopodium subglabrum (S. Wats.) A. Nels., commonly called Smooth Goosefoot, is a rare, shallow-rooted annual plant (Figure 1) found in the prairie provinces of Canada. Prior to 1990 only small numbers of this species had been observed at 20 sites in Canada (Smith and Bradley 1990*). Search efforts from the mid-1990s on resulted in the discovery of new populations in five Sand Hill regions in Saskatchewan and Manitoba. In 2004, the highest number of individuals ever recorded in Canada was observed, suggesting that this species has a strong temporal component to its rarity. The objective of this paper is to document these recent findings and determine their conservation implications.

Habitat

Chenopodium subglabrum populations occur in the Aspen Parkland, Moist Mixed Grassland, and Mixed Grassland Ecoregions of the Prairie Ecozone (Acton et al. 1998). Within this ecological area, *C. subglabrum* is found in Mixed Grasslands with sandy soils. The populations in Saskatchewan and Alberta are isolated from each other as the land in between them is largely cultivated. The Manitoba populations are particularly isolated, being approximately 500 km from the nearest *C. subglabrum* population in Saskatchewan and about 350 km from the nearest population in North Dakota (Schmoller 2002*). This fragmentation is natural since *C. subglabrum* does not generally grow on the silty and clayey soils that occur in between the various sand hills. The populations that occur along the South Saskatchewan River are less isolated than the ones growing in the sand hills to the south since habitat along the river is largely undisturbed.

Chenopodium subglabrum is an early successional habitat specialist growing typically in the stabilizing

FIGURE 1. Illustration of *Chenopodium subglabrum*. Line drawing by D. B. Robson.

TABLE 1. Nationally and provincially rare plants associated with *Chenopodium subglabrum*.

		Associated Species	
Province	Sand Hill	Nationally rare [1]	Provincially rare [2]
Alberta	Dominion	Nodding Umbrella-plant (*Eriogonum cernuum*) Sand-verbena (*Tripterocalyx micranthus*)	Bur Ragweed (*Ambrosia acanthicarpa*) Annual Skeleton-weed (*Shinnersoseris rostrata*)
Saskatchewan	Dundurn	Hairy Prairie-clover (*Dalea villosa* var. *villosa*) Sand-dune Wheatgrass (*Elymus lanceolatus* ssp. *psammophilus*)	
	Elbow	Western Spiderwort (*Tradescantia occidentalis*)	Sand Nut-sedge (*Cyperus schweinitziii*)
	Great	*Eriogonum cernuum*	*Ambrosia acanthicarpa* Wingless Bugseed (*Corispermum villosum*) *Shinnersoseris rostrata*
	Pelican Lake	*Dalea villosa* var. *villosa*	
	Seward	*Elymus lanceolatus* ssp. *psammophilus*	*Ambrosia acanthicarpa* *Corispermum villosum* *Shinnersoseris rostrata*
Manitoba	Routledge	Sand Bluestem (*Andropogon hallii*) *Tradescantia occidentalis*	Indian Rice-grass (*Achnatherum hymenoides*) *Cyperus schweinitziii* Purple Ball Cactus (*Escobaria vivipara*) Louisiana Broomrape (*Orobanche ludoviciana*) *Shinnersoseris rostrata*
	Brandon (Carberry)	*Dalea villosa* var. *villosa*	Winged Pigweed (*Cycloloma atriplicifolium*) *Achnatherum hymenoides*

1According to Argus and Pryer 1990
2 According to provincial Conservation Data Centres

sand at the edges of active dunes and blowouts, and along eroding, sandy river banks and coulees (Smith and Bradley 1990*; Robson 1997a; Lamont and Gerry 1998*). It is generally found on south- or west-facing actively eroding slopes, at the edge of stabilizing sand and sometimes in dune slacks. Populations tend to occur in discrete units clustered around active dunes and are typically highest in areas of finer and more compacted sand. Given that *C. subglabrum* was found historically along the South Saskatchewan River, it is possible that much of this species' habitat disappeared when Gardiner Dam was built on the South Saskatchewan River in the late 1960s, flooding the sand bars and terraces. Dynamic factors such as grazing, erosion and fire may aid in destabilizing sand, resulting in more habitat for *C. subglabrum* (Robson 1999).

Commonly associated species include the following: Indian Rice-grass (*Achnatherum hymenoides*), Sand Grass (*Calamovilfa longifolia*), Narrow-leaved Goosefoot (*Chenopodium pratericola*), Canada Wild Rye (*Elymus canadensis*), Northern Wheat-grass (*Elymus lanceolatus* ssp. *lanceolatus*), Prairie Sunflower (*Helianthus petiolaris* ssp. *petiolaris*), Hairy Golden-aster (*Heterotheca villosa* var. *villosa*), Skeleton-weed (*Lygodesmia juncea*) and Lance-leaved Psoralea (*Psoralidium lanceolatum*) (Smith and Bradley 1990*; Robson 1997a). Shrub cover often includes: Common Bearberry (*Arctostaphylos uva-ursi*), Hoary Sagebrush (*Artemisia cana* ssp. *cana*), Creeping Juniper (*Juniperus horizontalis*) and Sandbar Willow (*Salix exigua* ssp. *interior*) (Smith and Bradley 1990*; Robson 1997a). *Chenopodium subglabrum* is also associated with six nationally rare and eight provincially rare plants in various locations (Table 1).

Chenopodium subglabrum is an annual plant with bisexual flowers (Clements and Mosyakin 2004). Flowering occurs from June to August and seed production in August and September (Wallis and Wershler 1988). Although no studies on *C. subglabrum* pollination have been performed, other species in this genus are wind- or self-pollinated (Johnson and Ward 1993; Royer and Dickinson, 1999). The distances that *C. subglabrum* pollen travels is unknown. Since the wind-pollinated *C. pratericola* often occurs in the same habitat with *C. subglabrum*, hybridization may be possible, although it has not been observed (Bassett and Crompton 1982).

The fruits and seeds of *C. subglabrum* lack structures that would aid in wind (i.e., hairs) or animal (i.e., burs or fleshy fruits) dispersal although the seeds may ad-

here to wet fur. The seeds likely fall close to the parent plant and may be buried by shifting sand, or travel short distances in the winter over snow crust. This means that the main exchange of genetic material between populations would occur via pollination. Lamont and Gerry (1998*) asserted that dry weather could limit its germination. The dramatic increase in the number of individuals observed at most sites in Saskatchewan in 2004 coupled with the observation that late summer was unusually wet and cool suggests that maximum seed germination occurs under moist conditions. The seeds can likely remain dormant for several years (Robson 1999). This dormancy can last at least eight years; at the Beaver Creek site plants were observed in 1996 and 2004 but not in the years in between. There may be dormant seeds present in stabilized areas that would germinate under appropriate climatic conditions if the area were denuded of its vegetative cover.

No attempts to propagate the species for seed production have been attempted. If seeds were harvested from the wild and grown in a greenhouse the seeds from those plants could be introduced back into the wild. However, given the species' sensitivity to climate conditions, the seeds may not germinate in the wild the following year making assessment of the introduction success difficult to ascertain.

Chenopodium subglabrum is both a halophyte (i.e., salt-loving plant) and a xerophyte (i.e., dry-loving plant) making it a stress-tolerant species (Grime 1979). Plants in the Chenopodiaceae are generally non-mycorrhizal (Mukerji et al. 2000). Since *C. subglabrum* grows in areas of active sand where mycorrhiza are usually not abundant, it is probably normally non-mycorrhizal.

At several sites in Alberta and Saskatchewan there were specimens of *C. subglabrum* that had been grazed. Grazing may have been by cattle or wildlife. Some grazed plants produced side shoots to compensate for stem loss. A report on Ord's Kangaroo Rat (a nationally rare mammal) ecology noted that there were seeds of *C. subglabrum* found in their pouches and food caches so seed predation occurs (Lamont and Gerry 1998*). The growth of several plants observed appeared to be inhibited by an unidentified purplish fungus infecting the leaves.

The Grassland Natural Region is one of the most threatened natural regions in Canada. Over two-thirds of the Mixed Grassland has been lost to cultivation or other development (Wallis 1987). Although some sandy plains have been cultivated, the hilliest areas have not been. The main limiting factors affecting *Chenopodium subglabrum* are its natural narrow preference for unstabilized sites within dune fields and loss of natural habitat through succession. Large areas of once active sand have become stabilized over the last fifty years. The active sand surface of some dunes in the Milk River Sand Dunes of Alberta has been reduced by 50% to 75% over 40 years (Wallis 1987). In the Middle Sand Hills of Alberta, 90% of the sand that was active in 1950 is now stabilized (Wallis 1987). Hugenholtz and Wolfe (2005) estimate that stabilization rates in the Great Sand Hills of Saskatchewan have ranged from 7.2 to 10.5 ha/yr in the northern portion and 1.3-1.4 ha/yr in the southern portion since 1946. Stabilization rates from 1944 to 1996 in the Elbow Sand Hills have ranged from 0.4 to 1.9 ha/yr (Hugenholtz and Wolfe 2005). In the Seward Sand Hills stabilization rates from 1970 to 1991 were estimated to be 1.2 to 3.8 ha/yr (Hugenholtz and Wolfe 2005). The Tunstall Sand Hills stabilization rates from 1969 to 1991 were estimated to be 0.6 to 3.6 ha/yr (Hugenholtz and Wolfe 2005). In Manitoba only one of the six sand hills still has active dunes (Wolfe 2001). The Brandon (Carberry) Sand Hills stabilization rate from 1928 to 1990 has ranged from 1.8 to 17.7 ha/yr (Hugenholtz and Wolfe 2005; Wolfe et al. 2000).

While the exact mechanisms are unclear, a combination of drought conditions and land use appears to be influential in dune stabilization (Hugenholtz and Wolfe 2005; Wolfe et al. 2001, 2002). If current trends continue, rare native plants that now have dangerously low populations could be eliminated entirely. However, Wolfe and Thorpe (2005) speculate that climate change may result in a potential increase in the susceptibility of sand hills to erosion, possibly reversing this stabilization trend.

Exotic invasive weeds are becoming more common in dune areas and have the potential to usurp *C. subglabrum* habitat (Robson 1997a). Exotic plants observed in the same habitats with *C. subglabrum* include: Crested Wheat-grass (*Agropyron cristatum*), Lamb's-quarters (*Chenopodium album*), Leafy Spurge (*Euphorbia esula* var. *esula*), sweet-clover (*Melilotus* spp.) and Russian-thistle (*Salsola tragus*) (Wallis and Wershler 1988; Schmoller 2002*; Robson et al. 2005). Oil and gas exploration and extraction, and to a lesser extent recreation are also potential threats (Wallis 1987; Robson 1997a; Lamont and Gerry 1998*).

Distribution

Chenopodium subglabrum is found in the prairie provinces of Canada, south to Utah and Colorado, west to Washington and Nevada, and east to the Dakotas, Nebraska and Iowa (Figure 2) (Clements and Mosyakin 2004). The populations in Manitoba, Washington, Nevada, Utah, Colorado and Iowa appear to be disjunct from the species' main range (Clements and Mosyakin 2004).

In Alberta there are populations of *C. subglabrum* in five different regions of sand hills: Grassy Lake, Middle, Rolling Hills Lake, Dominion and Pakowki Lake Sand Hills. In Saskatchewan, *C. subglabrum* has been collected in 11 different sand hill regions: Bigstick-Crane Lakes, Birsay, Burstall, Cramersburg, Dundurn, Elbow, Great, Seward, Pelican Lake, Piapot and Tunstall Sand Hills. In southwestern Manitoba *Che-*

nopodium subglabrum populations are found in the Routledge (White and Johnson 1980; Robson et al. 2005) and Brandon (Carberry) Sand Hills.

Due to the annual nature of this species, the population numbers fluctuate widely. Data collected in 2004-2005 supports this hypothesis. At several Saskatchewan locations fewer than 50 individuals were found in the late 1990s but several hundred were observed in 2004. In the Routledge Sand Hills of Manitoba, 19 plants were observed in 2004 but 68 were seen in 2005. Population fluctuations, possibly in response to climate, make it difficult to accurately estimate the number of plants and the vulnerability of populations. In 2004 there were an estimated 8400 plants growing in Canada; in other years only a few hundred to several thousand plants were observed. However, even though plants may not be growing at a site in a given year, seeds are likely present in the seed bank.

The largest populations occur in the Great and Seward Sand Hills of Saskatchewan, and in the Grassy Lake Sand Hills of Alberta. Based on the observed fluctuations in population size and recognition that at any given year there are some *C. subglabrum* seeds dormant in the seed bank, there are likely between 5 000 and 10 000 plants in Canada. The following is an overview of populations in the three provinces of occurrence.

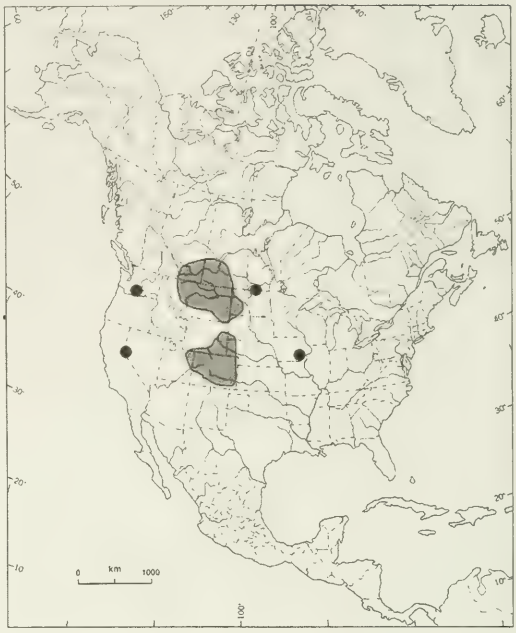

FIGURE 2. Distribution of *Chenopodium subglabrum* in North America.

Alberta

The only Alberta site visited recently (in 2004) was Lost River. Most population research on *C. subglabrum* in Alberta was conducted in the late 1980s (Table 2). Since such a long time has passed since these sites were visited, the dunes may have stabilized further, reducing available habitat.

Saskatchewan

Extensive *C. subglabrum* survey work was done in the mid to late 1990s in the sand hills of Saskatchewan (Robson 1997a; Lamont and Gerry 1998*). Since the first status report was written in 1990 (Smith and Bradley 1990*) new populations have been discovered in the Bigstick-Crane Lakes, Seward, Great and Tunstall Sand Hills (Robson 1997b; Nelson Dynes & Associates 1998*; Lamont and Gerry 1998*) (Table 3). This is balanced somewhat by the apparent loss of five populations where no plants have been observed for at least four decades. The Dundurn, Elbow, Great and Seward Sand Hills locations were visited as recently as 2004.

TABLE 2. Locations and population data for *Chenopodium subglabrum* in Alberta.

Location	Population	Last observation[1]	Population size
Dominion Sand Hills	Lost River	2004	5-50
Grassy Lake Sand Hills	Barnwell	1988	8
	Purple Springs	1988	30
	Turin	1986	100-200
Medicine Lodge Coulee	Medicine Lodge Coulee	1995	?
Middle Sand Hills	Cavendish	1987	?
	Hilda	1988	3
Pakowki Lake Sand Hills	Pakowki Lake North	1980	4
Rolling Hills Lake Sand Hills	Lonesome Lake	1988	1
Estimated size of the population in Alberta [2]			200-300

[1] Data obtained from Smith and Bradley (1990*)

[2] Calculated by adding the minimum number of plants observed or the maximum number of plants estimated at each site and rounding up or down.

TABLE 3. Locations and population data for *Chenopodium subglabrum* in Saskatchewan.

Location	Population	Last observation[1]	Population size
Bigstick-Crane Lakes Sands Hills	Bigstick Sand Hills	1998	21-80
	Crane-Lake Sand Hills	1997	311
	Tompkins	1997	21
Birsay Sand Hills	Dunblane	1961	?
Broderick	Broderick	1989	?
Burstall Sand Hills	Empress	1985	?
	Burstall	1997	202
Cramersburg Sand Hills	Cramersburg	1997	179
Dundurn Sand Hills	Beaver Creek	2004	1-4
	Beaver Creek East	1952	?
	CFB Dundurn	1997	6
Elbow Sand Hills	Bridgeford	1968	?
	Elbow	2004	288-500
	Head of Qu'appelle	1879	?
Great Sand Hills	Sandhill Stockman's Association	2004	2018-3796[2]
	Diamond Ranch	1997	435
	Heck Stockman's Association	2004	18-330[2]
	Signal Stockman's Association	2004	36-330[2]
	Watson's	2004	156 + 330[2]
McMahon	McMahon	1949	?
Pelican Lake Sand Hills	Caron	2002	<10
Piapot Sand Hills	Piapot	1983	?
Patience Lake	Patience Lake	1986	?
Seward Sand Hills	SSH 1	1996	55-540[2]
	SSH 2	2004	39-1000
	SSH 3	2004	13-330
	SSH 4	2001	90-540[2]
	SSH 5	2001	10-540[2]
	SSH 6	2001	2
	SSH 7	2001	1
Tunstall Sand Hills	Bitter Lake	1997	11
Estimated population in Saskatchewan [3]			5000-9700

[1] Data obtained from Harms (1990); Smith and Bradley (1990*); J. & W. Resource Management Consulting (1997*); Robson (1997a); Lamont and Gerry (1998*); Nelson Dynes & Associates (1998*).
[2] Estimated number of plants in 2004; determined by multiplying the number of dune fields present in the area by the average number of plants found at other dunes in the same area.
[3] Calculated by adding the minimum number of plants observed or the maximum number of plants estimated at each site and rounding up or down.

TABLE 4. Locations and population data for *Chenopodium subglabrum* in Manitoba.

Location	Population	Last observation	Population size
Routledge Sand Hills	Routledge	2005	68-75
	Oak Lake	1959	?
Brandon (Carberry) Sand Hills	Spruce Woods	2005	9-25
Estimated size of the population in Manitoba [1]			77-100

[1] Calculated by adding the minimum number of plants observed or the maximum number of plants estimated at each site and rounding up or down.

Manitoba

Although the species was found near Oak Lake in 1959 it was not observed again until 2004 when it was rediscovered (The Manitoba Museum voucher specimen catalogue # 37136) near Routledge (Robson et al. 2005) (Table 4). The active dunes in the Brandon (Carberry) Sand Hills were also searched for *C. subglabrum* in 2004 but no plants were found. However, in 2005 a small population of nine plants (The Manitoba Museum voucher specimen catalogue # 37859) was located. Two plants were found in the same area in 2006. This is the first record ever for this location and represents a range extension for this species of approximately 100 km east.

Evaluation

Significance

Chenopodium subglabrum plays a role in dune stabilization, being one of the few plants that can colonize active sand. Several related species are important economically, including Quinoa (*C. quinoa*), grown for its seeds, and Good King Henry (*C. bonus-henericus*), grown for its leaves (Everett 1981). The aboriginal peoples of the western United States consumed seeds of *Chenopodium pratericola* and Fremont's Goosefoot (*C. fremontii*) (Smith and Bradley 1990*).

Rarity Status

Chenopodium subglabrum was listed by the Committee on the Status of Endangered Wildlife in Canada in 2006 as being a threatened species in Canada. Legal protection of this species via the *Species at Risk Act, 2003* will likely occur in the next few years. This species is considered rare in all three prairie provinces (Packer and Bradley 1984; Maher et al. 1979; White and Johnson 1980) but is not yet protected by any provincial legislation. This species is not protected by any legislation in the United States.

The NatureServe ranks are Global G3G4 (globally vulnerable to apparently secure), Canada N2 (nationally imperiled), Alberta S1 (provincially critically imperiled), Saskatchewan S2 (provincially imperiled), and Manitoba S1 (provincially critically imperiled). The United States ranks are: Montana S1 (critically imperiled in the state), North Dakota S1 (critically imperiled in the state), Nebraska S3 (vulnerable in the state) and Wyoming S3 (vulnerable in the state) (NatureServe 2005*). In the remainder of the states where it occurs it is has either not been ranked (e.g., Colorado, Idaho, Kansas, Nevada, Oregon, South Dakota, Utah and Washington) or is considered unrankable due to a lack of information (e.g. Michigan) (NatureServe 2005*).

Future Outlook

Chenopodium subglabrum is restricted to sandy habitats in the prairie provinces that are geographically isolated from one another. Due to *C. subglabrum*'s annual nature, it experiences large fluctuations in population size from year to year. Dune stabilization has been occurring at a high rate in all of the sand hill habitats where this species occurs. Increased pressure on these ecosystems from the oil and gas industry, and encroachment of exotic weeds further threaten this species.

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Summary Movements and Impact of Individual Striped Skunks, *Mephitis mephitis*, on Duck Nests in Saskatchewan

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Striped Skunks (*Mephitis mephitis*) are important predators of duck eggs in the Canadian prairies. We estimated the impact of individual Striped Skunks on duck nests by intensive observations of foraging movements and depredation of duck nests in southern Saskatchewan, 1993-1994. Nightly, skunk movements were variable (range 0-20 km per night), and did not differ among seasons for females, or between males and females during the parturition/rearing season. Overall, nightly movement of Striped Skunks averaged 7.4 km for females (SD = 5.9 km, n = 20 females) and 6.7 km for males (SD = 3.2 km, n = 5 males). During 1 873 h of radio-tracking, we observed depredation of 10 duck nests by 8 skunks (7 F, 1 M). Using our observed estimate of one depredation for every 187 h, and averaged nightly activity of 8-10 h per night, we estimated that individual skunks find one duck nest every 19-23 nights. Thus, during the 60-day nesting season for ducks (mid-May to mid-July), individual skunks probably find 2-3 duck nests. These observations reinforce the growing evidence that, at normal duck nest densities (<2.5 nests/ha), depredation of eggs by Striped Skunks is opportunistic, and the impact of Striped Skunks on duck nests is a direct function of Striped Skunk abundance.

Key Words: Striped Skunk, *Mephitis mephitis*, duck, movement, nest predation, prairie, predator ecology, Thickwood Hills, Saskatchewan.

Predation on eggs is an important limiting factor for many bird populations (Ricklefs 1969; Martin 1995). In the grasslands of North America, population decline of many species of ground nesting birds is attributed to increased predation on eggs during the breeding season (Böhning-Gaese et al. 1993). Of these birds, ducks (Anatidae) nesting in the prairies of Canada and the United States experience high predation rates on their nests. The primary mammalian predators are Striped Skunks (*Mephitis mephitis*), Red Foxes (*Vulpes vulpes*), Raccoons (*Procyon lotor*), American Badgers (*Taxidea taxus*) and Coyotes (*Canis latrans*). The impact of these predators on duck nest success is well recognized (Klett et al. 1988; Johnson et al. 1989; Pasitschniak-Arts and Messier 1995). However, the contribution of individual animals is poorly understood, yet is critical for management and mitigation of nest predation.

In the parklands of Saskatchewan, the Striped Skunk is an important predator of duck eggs (Pasitschniak-Arts and Messier 1995), yet it depredates duck nests opportunistically (Larivière and Messier 1997a, 1998a). This suggests that the impact of skunks on duck nest success is the result of "chance" encounters with duck nests as skunks forage for other foods such as small mammals and insects (Greenwood et al. 1999). Therefore, the impact of Striped Skunks on duck nests should be a function of (a) habitat selection patterns (do skunks use habitats where ducks nest?), (b) movement rates (the longer the movements by skunks, the greater the chances of discovering a duck nest), and (c) density of skunks (the more skunks, the greater the impact on duck nests). A recent experiment suggested that individual predators were unlikely to key on duck nests at densities <2.5 nests/ha (Larivière and Messier 1998a). Furthermore, partial depredation of duck nests by Striped Skunks commonly occurs (Larivière and Messier 1997a; Ackerman 2002), suggesting that duck eggs may not be a preferred food of skunks or that their importance may be marginal to the overall nutrition of Striped Skunks. An estimate of the impact of individual Striped Skunks on duck nests would help further our understanding of the role that duck eggs play in the foraging ecology of this carnivore. Herein, we estimate the impact of individual Striped Skunks on duck nests by combining intensive radio-tracking and observations of free-ranging Striped Skunks in the Prairie Pothole Region of Saskatchewan, Canada.

Methods

We conducted this study ca. 80 km northwest of Saskatoon in the Thickwood Hills of southcentral Saskatchewan, Canada (52°45'N, 107°08'W). In 1993, the area (ca. 220 km^2) was dominated by farmland and interspersed with many wetlands and stands of trem-

bling aspen (*Populus tremuloides*). Cropland represented 66% of the area, and was primarily used for the production of grain (e.g., wheat, barley, rye, and oats), and oil crops (e.g., canola and flax). Other less common crops included peas, lentils, buckwheat, and canary seed. Woodland and areas managed for nesting waterfowl (mostly dense nesting cover) occupied 11% and 9% of the landscape, respectively. Managed nesting areas consisted mostly of dense nesting cover, hay land, and idle pastures. Fields of dense nesting cover were sown with various tame and wild grasses to create prime habitat for nesting waterfowl. Small or linear cover types such as wetlands, rights-of-way, farmsteads, and miscellaneous habitats represented 8%, 4%, 1%, and 1% of the land available, respectively. Topography was gently rolling, and an extensive network of roads divided the land.

In 1993, Striped Skunks were live-trapped using opaque-sided livetraps (Dura-Poly livetraps, Ram Supplies, Birtle, Manitoba). Captured skunks were anesthetized with halothane and Telazol® (Larivière and Messier 1996a, 1996b), and equipped with motion-sensitive radio-collars (Telonics Inc., Mesa, Arizona, USA). Skunks were handled and released at site of capture.

Radio-collared animals were located and tracked by a single observer on foot from 18:00 to 06:00 h, during the period of greatest activity (Larivière and Messier 1997b). During tracking, a single observer followed the foraging skunk while remaining downwind, and usually within 15-50 m of the animal (Larivière and Messier 1998b). This distance allowed precise location of focal animals every 15 min, and allowed observation of foraging behavior. For short movements (<100 m), distance from previous location was estimated by observer. Locations immediately following an observer-induced defensive posture (n = 198: Larivière and Messier 1996c) were discarded from analyses because of observer disturbance (Larivière and Messier 1998b). At dark, we used night-vision equipment (AN-PVS 5C, Bill's Electronics, Mildmay, Ontario) to continue observations (Larivière and Messier 1998b). Encounters with duck nests typically were easy to detect because of the flushing hen (Larivière and Messier 1997a) or repeated visits to the nest (Larivière and Walton 1998). Depredated nests were investigated immediately following departure of the skunk, and usually reexamined the following day.

For each location, we recorded position of the focal skunk using a Global Positioning System (GPS) unit. We estimated accuracy of our GPS as ± 250 m. To overcome biases associated with the inaccuracy of our GPS on short movements, we only considered the total distance traveled by each skunk during the 12-h tracking period (sum of all 15-min movements). We also only considered complete 12-h blocks for which onset and cessation of activity were known. Missing values (typically caused by delays of the GPS unit to obtain fixes in forested habitats) for ≤2 intervals per night were approximated by the nightly mean of 15-min travel distances. Sessions with >2 missing values were discarded from analyses. Biological seasons for Striped Skunks were identified as pre-parturition (1 April-14 May), parturition/rearing (15 May- 30 June), pre-dispersal (1-31 July), and dispersal (1-31 August).

Each summer (May-August), >50% of radio-collared animals died or dispersed outside the study area (Larivière and Messier 1998c). Thus, the resulting data set was not balanced, and precluded use of repeated-measures analyses, and comparison among seasons. Therefore, we used a one-way analysis of variance to test for effects of season on movements. To avoid biases caused by animals tracked >1 night in a given season, we used the mean distance traveled for each skunk in each season (weighted mean, only one value per animal per season). Because some skunks were tracked during more than one season and they may not have been independent, we used an alpha value of 0.01 to remain conservative and reduce the chance of a Type 1 error.

Results

During 1993 and 1994, we obtained complete movement information for 63 12-h tracking sessions (11 in 1993, and 52 in 1994) on 25 Striped Skunks (5 M, 20 F). Because no skunks were radio-tracked during both years, we pooled data from 1993 and 1994 for analyses.

Nightly movements of female Striped Skunks during pre-parturition (mean = 4.2 km, SD = 4.9 km, n = 4), parturition/rearing (mean = 7.2 km, SD = 6.1 km, n = 19), pre-dispersal (mean = 5.6 km, SD = 3.0 km, n = 8), and dispersal (mean = 3.0 km, SD = 3.1, n = 2) were not statistically different ($F_{3, 29} = 0.70$, $P = 0.56$). Distance traveled during 12-h tracking sessions were variable and ranged from 0.0 to 20.3 km per night (mean = 6.2 km, SD = 5.2 km, n = 33 female-season). When we considered only one value for each female (weighted mean; average of all seasons), nightly movements averaged 7.4 km (SD = 5.9 km, n = 20 females).

During the parturition/rearing season, movements of males (mean = 6.7 km, SD = 3.2 km, n = 5) did not differ (t-test, df = 22, P = 0.84) from movement of females (mean = 7.2, SD = 6.1 km, n = 19). Movements of all skunks during the parturition/rearing period averaged 7.1 km (SD = 5.6 km, n = 24 skunks).

During spring and summer 1993 and 1994, we radio-tracked Striped Skunks for 1873 h (858 h in 1993, and 1015 h in 1994). During radio-tracking, we observed depredation of 10 duck nests (4 in 1993, 6 in 1994), thus averaging one depredation event for every 187 h of radio-tracking (1 for 215 h of radio-tracking in 1993, and 1 for 169 h in 1994). Observed depredation events were caused by 8 Striped Skunks (7 females, 1 male). Observed depredation events occurred between 9 June and 9 July in 1993, and between 15 May and 20 July in 1994.

From our observations, we extrapolated the number of nests depredated by a skunk during the duck nesting season. First, using our rate of discovery of 1 nest every 187 h of tracking, and allowing an average 8-10 h of foraging movements per night (Larivière and Messier 1997b), we estimated that individual skunks found 1 duck nest for every 19-23 nights of foraging. Considering the duck nesting season lasts approximately 60 d (mid-May until mid-July), then individual skunks may find 2-3 duck nests per season. However, because skunks foraging in dense vegetation may have depredated duck nests without us noticing, this estimate represents a minimum number, but our close-range observations (typically <50 m) and use of night-vision equipment suggests that we did not miss many depredation events.

Discussion

Our results clearly show that the foraging behavior of Striped Skunks consists of highly variable foraging movements and opportunistic, but infrequent, depredation of duck nests. The variable movements we observed within and among seasons, or between sexes, precluded detection of statistical differences. However, the trend suggested that movements were shorter during the pre-parturition season, higher during parturition season, and declined temporally thereafter. Interestingly, the decline in skunk movements over time coincides with the steady increase in availability of both small mammals and insects over time (Larivière and Messier 2000). Although we could not statistically link movements of skunks and food abundance because of only four sampling periods, we nonetheless observed apparently reduced skunk movements over time as prey abundance increased. An experiment done with simulated nests in our study area in 1995 indicated that increases in availability of food (chicken eggs) caused a reduction of activity and home ranges in female Striped Skunks (Larivière and Messier 2001a).

Movement rates observed in our study are the largest reported for this species. However, most previous studies of skunk movements relied on distance between consecutive den sites (Shirer and Fitch 1970), maximum distance from the den during any given night (Verts 1967), or distance between recapture sites (Bjorge et al. 1981). Our study is one of three that reported actual distance moved from telemetry locations. In Illinois, daily movements of Striped Skunks averaged 1.7 km for males (n = 4) and 1.4 km for females (n = 9) (Storm 1972). In North Dakota, nightly movements ranged from 0.0 to 9.3 km for 26 females (mean = 2.7 km), and from 0.4 to 10.5 km for males (mean = 3.3 km) (Greenwood et al. 1985). We believe our values are higher because we collected a more accurate description of movement paths by collecting locations at closer intervals (i.e., every 15 min) whereas animals were located every 2 h in North Dakota (Greenwood et al. 1985), and at intervals varying between 10 and 120 minutes in Illinois (Storm 1972).

Two additional explanations may explain the long movements of Striped Skunks in our study area. The first may be the composition of the landscape. Our study area was primarily cropland (66% of study area), a habitat that provides low abundance and diversity of foods for skunks (Larivière and Messier 2000). Not surprisingly, Striped Skunks in our study area avoided cropland when foraging (Larivière and Messier 2000). Thus, large amounts of cropland may contribute to increased movements as skunks were forced to travel across large fields to access prime habitats embedded therein. Nightly movements of Striped Skunks may be lower in large patches of continuous foraging habitats, a phenomenon that would help explain the typically higher nest success of ground-nesting birds in large patches of non-fragmented habitat (Pasitschniak-Arts and Messier 1996; Ball et al. 1995).

Another explanation may be related to the amount of food in the landscape. Possibly, food abundance may have been lower in our study area compared to previous studies, thus contributing to longer movements. Food supplementation experiments on Striped Skunks and other species typically yield lower activity, smaller ranges, and shorter foraging bouts (Boutin 1990; Larivière and Messier 1998a). However, because we have no way of comparing food abundance among studies, we can only speculate on whether differences existed between our study area and those used in previous studies.

Managers attempting to mitigate predation on duck nests need to know whether high predation rates occur because of specialized foraging by a few individuals depredating numerous nests, or simply by a high abundance of individuals each depredating only a few nests. Previous observations of skunk foraging behavior suggested that predation is incidental to foraging for other foods (Vickery et al. 1992; Larivière and Messier 1997a), and that greater predation rates are explained by a greater abundance of nest predators (Larivière and Messier 1998a).

Our study suggests that individual Striped Skunks in the Canadian prairies find between 0 and 3 duck nests per year. In fact, we observed only two skunks depredate more than one duck nest in any given year (both cases of females depredating two nests). Because our study area was located where nesting cover was common (managed nesting areas represented 9% of the study area), we believe our estimates probably are high because most areas of the Canadian prairies do not have 10% of the land as cover available for ducks, and hence probably hold fewer duck nests. Nonetheless, this suggests that availability of duck nests in the landscape is not high enough to warrant special foraging efforts; this reinforces the notion that nest depredation by Striped Skunks is strictly incidental (Larivière and Messier 1997a, 1998a, 2001b; Vickery et al. 1992). Finally, the rate of encounter suggests that the

impact of skunks on duck nests is directly related to skunk abundance, as was previously suggested (Larivière and Messier 1998a).

The impact of individual Striped Skunks on duck nests provides insight into the low success of management techniques that aim at educating individual predators. For example, conditioned-taste aversion had been unsuccessful under field conditions when mammals such as skunks and Raccoons were the main predators (Clark et al. 1996). We believe our data suggest that encounter rates with duck nests by individual predators are too low for such techniques to be effective, notwithstanding problems in causing aversion (Clark et al. 1996). At normal nest densities (<1 nest/ha), predators cannot subsist on eating duck eggs alone, and duck eggs only represent a marginal food item (Greenwood et al. 1999). Not surprisingly, foraging activity of Striped Skunks is directed at habitats where base prey such as insects and small mammals are most abundant, and not in areas managed for nesting ducks (Larivière and Messier 2000). Thus, management techniques that aim to increase nest success should be directed at reducing predator abundance locally (Garretson and Rohwer 2001), or reducing overall habitat suitability for predators with implementation of large-scale habitat programs through agricultural policies (e.g., Conservation Reserve Program in the United States, Reynolds et al. 2001).

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Life History Phenology and Sediment Size Association of the Dragonfly *Cordulegaster dorsalis* (Odonata: Cordulegastridae) in an Ephemeral Habitat in Southwestern British Columbia

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The life cycle of the dragonfly *Cordulegaster dorsalis* was studied over one year by systematic sampling of larvae in three intermittent headwater streams in southwestern British Columbia. We determined that larvae normally take three years to reach maturity, emerging throughout July and August. There is limited evidence suggesting a split cohort development, with early emergence after two years. Additionally, we tested whether larval instars were distributed randomly or if they occupied different sediment microhabitats. Smaller animals tend to be associated with smaller grained organic sediments, although there was high variation between the streams.

Key Words: Odonata, dragonfly, *Cordulegaster dorsalis*, ephemeral stream, life history, phenology, British Columbia.

Dragonfly larvae are often conspicuous and important predators in stream ecosystems. In British Columbia, the family Cordulegastridae is represented by a single species, *Cordulegaster dorsalis* Hagen. Cordulegastrids occur in lotic waters, usually in small streams, where larvae live as shallow burrowers in sediment (Cannings 2002). In southwestern coastal British Columbia, larvae of *C. dorsalis* are often found in small headwater streams that are subject to extreme episodic drying. In the interior of the province, the species is less common and is mainly associated with small, spring-fed streams. Adults of *C. dorsalis* normally fly from mid-May to early September, peaking in July (Cannings 2002). Published accounts of the life history, habitat associations or ecological requirements of *C. dorsalis* in its larval stage are sparse.

Kennedy (1917) estimated *C. dorsalis* larvae in central California may require as many as four years to develop. The larval development of cordulegastrids in Europe ranges from 2 to 5 years and may include split cohorts (Ferreras-Romero and Corbet 1999). Split cohort timing has been documented in other species in the genus (*C. boltonii* [Donovan] in Ferreras-Romero and Corbet 1999). Corbet (1999: 230) maintains it is possible to identify a winter critical size, below which larvae in the first year of development will enter diapause during the subsequent summer period, requiring another year's growth to reach metamorphosis. Such differential growth rates within a single cohort may be produced by staggered egg-laying times, food limitation or variability in the environment. Given the transitory nature of the streams used by *C. dorsalis*, it is possible that it exhibits plasticity in growth rates and emergence times in response to continual shrinking and rewetting of the streams.

Dragonfly larvae increase in size by three to four orders of magnitude as they develop. Microhabitat selection may have much to do with the physical constraints of size. Different species of burrowing odonates prefer certain sediment-size categories (Corbet 1999). *C. boltonii* has sediment-size preferences that vary with specific larval size classes (Prodon 1976 unpublished dissertation referenced in Corbet 1999). In contrast, *C. maculata* Sélys in Virginia is a habitat generalist, occuring in equal densities in both silts and sands (Burcher and Smock 2002). In general, small larvae of *C. boltonii* prefer much finer sediments than do larger larvae – larvae tend to select a particle size that offers the least obstruction to burrowing (Corbet 1999).

We report life-history observations (morphological measurements) of larval *C. dorsalis* over a one year period in three small headwater streams subject to late summer drying. We observed that large and small larvae did not occur together within pools. At the same time, we observed surprisingly high densities of odonate larvae in small, shrinking pools during late summer. We tested whether small and large larval instars occupy different sediment microhabitats and report life-history observations (morphological measurements) of larval *C. dorsalis* over a one-year period in three small headwater streams subject to late summer drying.

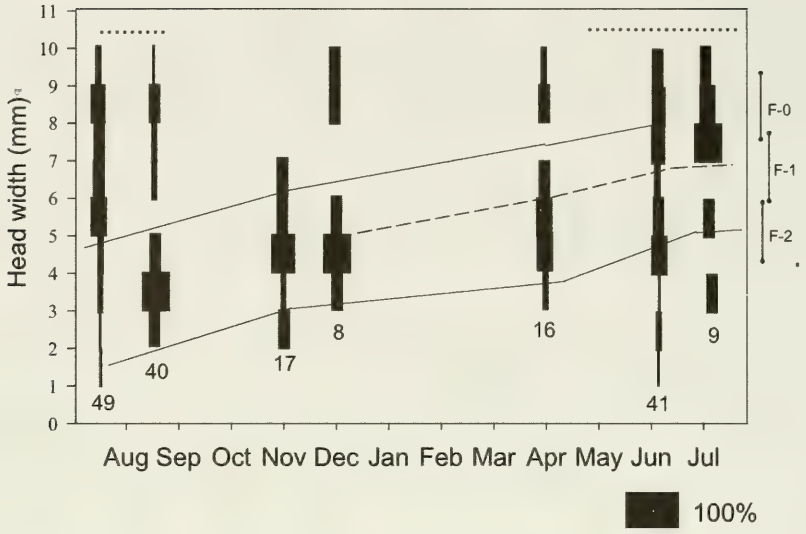

FIGURE 1. Life history patterns of *Cordulegaster dorsalis* shown for 2002-2003 — in G Creek (n = 175). Continuous lines ascending from left to right indicate inferred boundaries between successive hatching cohorts. The emergence period during late summer is shown (dotted line). Size ranges of the last three instars are indicated. The broken line indicates an alternate interpretation and represents the inferred boundary between the two components that could result from cohort-splitting in the two-year-old hatching cohort, thus distinguishing larvae that grow fast (above line) and slowly (below line). Numbers below columns indicate sample sizes for each sampling date. Widths of black bars for each interval of headwidth on a given date represent the relative fraction of the total sample that fell in that interval; total possible width for any given sampling date is represented by the black legend box labelled 100%.

Methods

Study Site

This study took place in the 5157 ha Malcolm Knapp Research Forest, located in Maple Ridge, British Columbia. The forest is located in the Pacific coastal rain forest, with a maritime climate of cool dry summers and warm wet winters (Naiman et al. 2000). We sampled *Cordulegaster dorsalis* larvae for life history characteristics and sediment associations in three streams within the forest (I, F and G streams; 49°18'40"N, 122°32'40"W), which were part of an ongoing riparian management experiment (see Kiffney et al. (2003) for site descriptions). Both F and G streams retained a 10 m forest buffer while I stream flowed through a 5-year-old clearcut. The dominant vegetation surrounding these creeks included Red Alder (*Alnus rubra*) and Vine Maple (*Acer circinatum*) with a canopy composed largely of Western Hemlock (*Tsuga heterophylla*), Western Redcedar (*Thuja plicata*) and Douglas-fir (*Pseudotsuga menziesii*). Vegetation adjacent to I stream consisted of shrubs, particularly Salmonberry (*Rubus spectabilis*) and Huckleberry (*Vaccinium ovatum*).

Life-history characteristics

We surveyed approximately 200 m each of I, F, and G streams in August, October and December of 2002 and April, July and August of 2003, collecting larvae using dip nets and hand sorting. We measured head width (Hdw max. distance between the lateral margins of the compound eyes), total body length (Tbl; max. distance between the mouthparts and the end of the cerci measured along the dorsal surface) and wingpad length to the nearest 0.1 mm with vernier-scale callipers. Using regression analysis we determined the scaling coefficient (reported as the slope of the line) for head width and body length. Size ranges of late instar classes were determined from the relationship between wingpad length and head width. Year class separation was analysed using wingpad to head width relationships together with visual assessment of size frequency distributions (after Ferreras-Romero and Corbet 1999). The level of significance was set at $P = 0.05$.

Sediments

The habitat associations of different size classes of larvae were characterized from August 2002 through April 2003. Sediment samples were collected at each point of larval capture and sieved into six size fractions (63 µm, 250 µm, 500 µm, 1 mm, 2 mm, 4 mm). Each sediment fraction was air-dried and weighed, then ashed at 550°C for 2 h and reweighed to obtain weights of both inorganic and organic fractions. Cumulative percent curves were used to determine the median particle size of each sample. We used linear regression to investigate the data for relationships between larval head width, median sediment size and organic fraction.

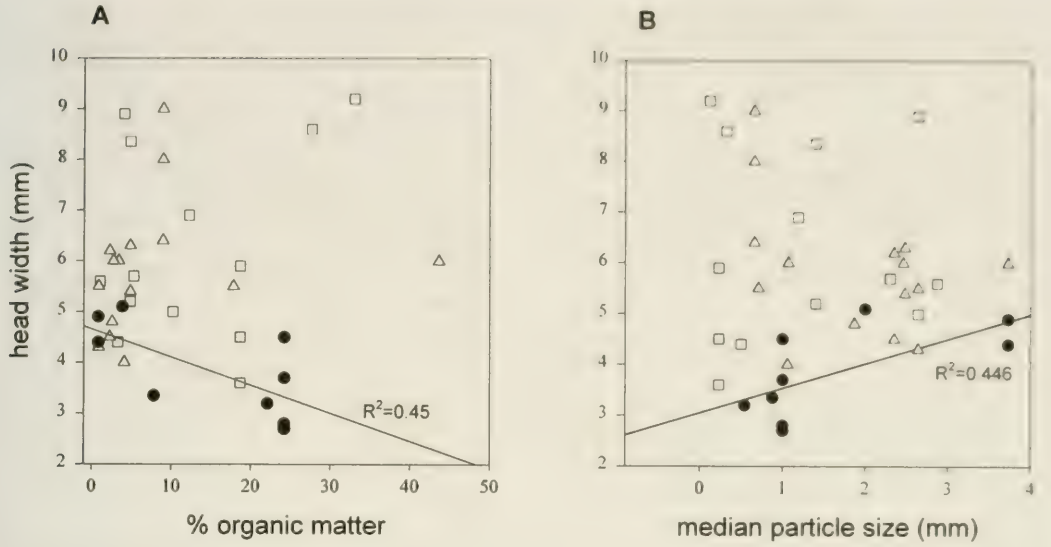

FIGURE 2. Relationship between larval head width of *Cordulegaster dorsalis* and sediment characteristics — (A) percentage of organic matter; and (B) median particle size. Regressions were significant for F Creek (closed circles) but not for G Creek (open squares) or I Creek (open triangles).

Results and Discussion

During August 2003 when sample sizes were largest, head width of F-0 (7.5 mm – 9.2 mm) and F-1 (6 mm – 7.8 mm) larvae overlapped, but wingpad lengths were discrete (3 mm – 5.5 mm in F-2, 6.9 mm – 10 mm in F-1 and 11.9 mm – 15.5 mm in F-0). Total body length and head width were correlated ($R^2 = 0.86$, $P < 0.001$, TBL = 4.49 HW – 0.59).

In G Creek, larvae of *Cordulegaster dorsalis* – derived from eggs that likely hatched in early summer – grew through late summer and early autumn (Figure 1). At the beginning of their second year most larvae had a head width between 2 mm and 5 mm. At the end of their second year of growth, larvae achieved headwidths between 5 mm and 8 mm. Emergence occurred at head widths greater than ca. 8 mm during July and August of the third year.

The pattern of development that we observed in G Creek (where sample size was greatest, $n = 180$) indicated that, in general, *C. dorsalis* larvae require three years to achieve metamorphosis. It is possible to interpret these data as evidence of a split-cohort in the second year with a "fast" group of larvae emerging following accelerated late summer to early fall growth at the end of their first year (Figure 1, dashed line). This interpretation would suggest a winter critical size of ca. 6 mm (Hdw; Figure 1). Sample sizes were too small in I Creek ($n = 30$) and F Creek ($n = 21$) to bolster a split-cohort interpretation; the Hdw of collected larvae generally support a three-year development.

Many Odonata retain a synchronized emergence period through the use of photoperiod cues (e.g. Aoki 1999; Burcher and Smock 2002). Some species of odonates appear to have both "slow" and "fast" components of the same cohort (Martin et al. 1991; Johnson et al. 1995; Ferreras-Romero and Corbet 1999). We present two possible development schedules for *C. dorsalis*: a split cohort with a "fast" component emerging after two years and a "slow" component requiring three years to complete development. Cordulegastridae are noted for their protracted larval development, a pattern that might be anticipated of shallow burrowers occupying small, cool streams (Corbet 1999). Two years would represent a remarkably short development time within this family, particularly given the known four-year development time for cordulegastrids in northern California (Kennedy 1917). A more complete record of larval growth rates is required before evidence of a slow and fast development in *C. dorsalis* can be dismissed; in the meantime, the data most strongly support a simple three-year development schedule.

During our surveys for larval development, we observed that small pools seldom contained both large and small larvae. Larvae were most abundant at median particle sizes between 1.5 mm and 2.5 mm. The head width of larvae was negatively associated with percent total organic content in F Creek (Figure 2a; $P < 0.01$; $R^2 = 0.451$) but no relationship was evident in either G or I creeks. Similarly, the head width of larvae was positively associated with median particle size in F Creek (Figure 2b; $P < 0.05$; $R^2 = 0.446$) while no relationship was evident in either G or I creeks. It should be noted that median particle and percent

organic matter are not independent measures; there is a negative correlation (r = –0.699). Post-hoc power analysis suggested that these results must be interpreted cautiously (*power* = 0.5134 organic; 0.5072 median particle).

All odonate larvae are opportunistic predators that will eat almost any type of prey they can detect and subdue (Burcher and Smock 2002). Since larger larvae will eat smaller larvae when they encounter them, it seems plausible that some form of habitat partitioning occurs to minimize intraspecific competition and cannibalism. How larvae are distributed at the microhabitat scale will largely determine the frequency of their interactions with conspecifics, affecting the probability of agonistic interactions. The presence or absence of other predators, such as fish, may also affect the microdistribution of larvae. Suhling (1999) demonstrated that small larvae of the gomphid, *Onychogomphus uncatus* (Charpentier), were significantly more abundant in sand where fish predation was also lowest while medium-sized and large larvae were most abundant in gravel and stones, respectively.

In our study, smaller larvae appeared to be associated with finer sediments with a higher organic fraction. There was a trend supporting larval size sorting relative to sediment microhabitats; however, these results must be interpreted conservatively since this pattern was evident in only one of the three streams surveyed and overall sample sizes were low. In previous habitat surveys of this genus, larvae of *C. bidentata* Sélys were most abundant at a mean grain size of 2.04 mm while *C. heros* Theischinger were most abundant at 2.79 mm (Lang et al. 2001). This is consistent with our finding that larvae of *C. dorsalis* were most abundant within medium sand sediments with a median grain size between 1.5 mm and 2.5 mm.

Although *C. dorsalis* larvae prefer smaller sediments as a group, our evidence is inconclusive regarding microhabitat partitioning amongst larval size classes. There are several alternative explanations for the size sorting we observed between small pools. Larvae may become trapped in these shrinking habitats in a nearly random fashion with respect to size, and the apparent sorting occurs post hoc through intraspecific predation. Smaller larvae would only survive in pools that have a low proportion of late instar larva when these habitats become isolated. Alternatively, the observed size sorting of large and small larvae may relate to a factor that is strongly correlated with sediment grain sizes such as current speed or oxygen levels.

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An Analysis of the Vascular Flora of Annapolis Heathlands, Nova Scotia

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A description and analysis of the vascular plant composition of heathlands in the Annapolis valley were undertaken to provide a basis for biodiversity preservation within a system of protected sites. Species presence and abundance were recorded at 23 remnant sites identified using topographic maps, air photos, and Nova Scotia Department of Natural Resources records. A total of 126 species was recorded, of which 94 were native and 31 introduced. The Annapolis heathland remnants are strongly dominated by *Corema conradii* with *Comptonia peregrina*, *Vaccinium angustifolium* and *Pteridium aquilinum* var. *latiusculum*. A number of species, including *Solidago bicolor*, *Carex tonsa* var. *rugosperma*, *Dichanthelium depauperatum*, *Lechea intermedia*, *Melampyrum lineare*, and *Rubus hispidus*, were characteristic of heathland remnants, although they usually contributed little to the total cover. The most frequent alien species were *Hieracium pilosella* and *Festuca filiformis*, but *Pinus sylvestris*, present at 7 of 18 sites, appeared to have the greatest impact in displacing native species. Species listed as at risk and sensitive in Nova Scotia, including *Helianthemun canadense*, *Hudsonia ericoides* and *Viola sagittata* var. *ovata*, occur in open disturbed sand in the *Corema* heathlands. Distinctive patterns of variation occur in several species and variation in crop relatives is noted with particular reference to the genera *Rubus* (blackberries), *Amelanchier* (Juneberries, Saskatoon) and *Vaccinium* (Blueberries). The available evidence suggests that the heathlands and sandy barrens in the Annapolis valley differ from those further west in Canada and from anthropogenic and coastal heathlands of Nova Scotia in their species composition including particularly the presence of *Corema conradii*, *Hudsonia ericoides* and *Amelanchier lucida*. The need to protect representative examples is supported.

Key Words: Heathlands, Annapolis valley, barrens, vascular plants, flora, Corema, Nova Scotia, Canada.

In 1921, legendary Harvard botanist Merritt Lyndon Fernald visited the Annapolis valley. He found extensive open heathlands. He noted: "near Berwick and from there to Wilmot were vast uncultivated plains carpeted, wherever dry enough, with a close growth of the New Jersey Pine barren *Corema conradii*, and, ... remnants of them near Middleton" (Fernald 1921). As recently as the 1960s open heathlands with scattered Red Pines (*Pinus resinosa*) occurred for many miles along the Evangeline Trail (Figure 1). It has been estimated that in pre-settlement times the actual area of heathland encompassed approximately 200 km^2. Today less than 3% of the original heathland vegetation remains in the Annapolis Valley (Catling et al. 2004), and even that is threatened by loss of natural ecological processes, invasive species and conversion of the landscape (Catling et al. 2004; Catling and Carbyn 2004). Protection of this ecosystem is important for the protection of (1) insect pollinators of adjacent crops; (2) protection of wild relatives of crops for crop improvement; (3) benchmark research examples; (4) teaching examples; (5) nature-related recreational opportunities; and (6) protection of biodiversity generally in connection with national and international accords. The only descriptions of Annapolis heathlands currently available (Fernald 1921; Roland 1946; Catling et al. 2004) are brief, non-quantitative, and insufficient as a basis for protection of biodiversity. Here we provide a description of remnants of natural heathland in the Annapolis Valley along with an indication of dominant species, rare and significant species, variation between sites and relationship to other eastern Canadian sand barrens. This is designed to provide a basis for further study and for the establishment of a system of protected sites.

Methods

Sites and data

The study area consists of 23 sites in the Annapolis Valley (Table 1, Figure 2). Sites are defined as areas surveyed separated by at least 0.5 km. Information from the Nova Scotia Department of Natural Resources and topographical maps were used to determine the most probable locations of heathland vegetation occurring on sandy soil.

At sites 1–19 abundance of vascular plants was recorded. Areas surveyed varied from approximately 0.5–61 hectares in extent. The majority of these 19 sites

FIGURE 1. Open heathland dominated by *Corema conradii* (Broom Crowberry) with *Pinus resinosa* (Red Pine). Photo by P. M. Catling in 2004 at site 8.

were visited on at least two occasions in 2003, with one visit in early summer and another in autumn. Approximately two hours were spent at each site on each visit. Species lists were made at each site (Table 2). An abundance value ranging from 0–5 was assigned to each species (1 = rare, 2 = uncommon, 3 = common, 4 = frequent and locally dominant, 5 = dominant) based on consensus of two or three observers. Although some larger sites were visited more often, almost all species recorded were recorded in the first hour of two visits. Time spent at sites was therefore considered to be adequate and the lists are thought to be essentially

TABLE 1. Site number and location of heathland study sites in the Annapolis Valley, Nova Scotia.

Site Number, Name	Latitude °	Longitude °
1 Evangeline Heathland E of 201	45.0059	–64.8882
2 Evangeline Heathland W of 201	45.0048	–64.8930
3 Trail Heathland	45.0005	–64.9004
4 Evangeline Main Heathland	45.0094	–64.8705
5 Brooklyn Street Wildlife Sanctuary	45.0872	–64.5245
6 Caribou Bog Heathland remnant	45.0377	–64.783
7 Trailer Park Heathland	45.0219	–64.8255
8 Exit 17 Heathland, NE corner	44.9992	–64.9411
9 Exit 17 Heathland, NW corner	44.9962	–64.9509
10 4 km W of Middleton	44.9204	–65.1048
11 W side of Middleton	44.9607	–64.9999
12 Evangeline Cemetary	44.9675	–64.9866
13 E side of Greenwood Military Base	44.9896	–64.8955
14 Aldershot Military Base behind shooting range	45.0966	–64.5333
15 Greenwood section	44.9833	–64.8873
16 Exit 17 far east	44.9974	–64.9470
17 Greenwood Military Base main site	44.9801	–64.9381
18 Greenwood Military Base satellite	44.9853	–64.9308
19 201 East near bog	44.9791	–64.9366
20 Plot – W of Whitman Road	45.0109	–64.8404
21 Plot – E of route 201	44.9992	–64.8854
22 Plot – N of route 201	44.9472	–65.0203
23 Plot – S of Ward Road	44.9681	–64.9367

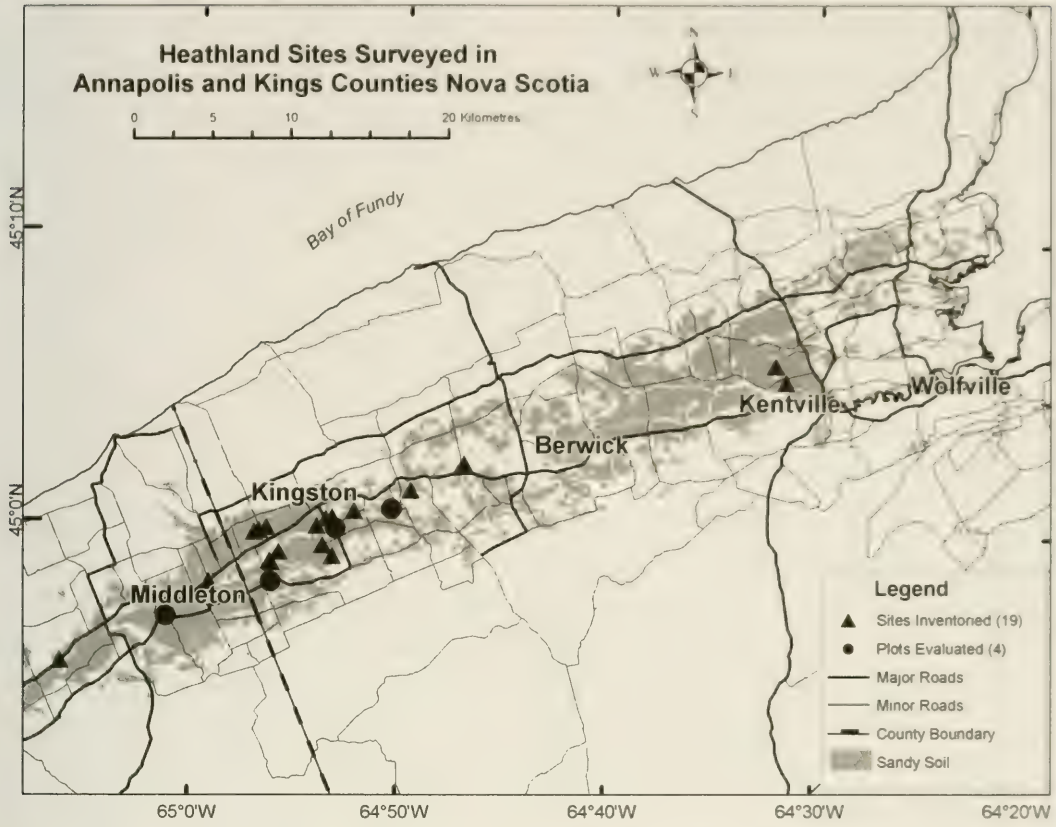

FIGURE 2. Heathland sites surveyed in the Annapolis Valley in 2004 (solid triangles) and location of plots evaluated for cover in 2005 (dots). The sandy soils of the valley (shaded) suggest the maximum extent of heathland.

complete. Voucher specimens collected at various sites were deposited in the vascular plant herbarium at Agriculture Canada in Ottawa (DAO). Status of plant species was determined by using Maher et al. (1978), the recent listing of species at risk (Nova Scotia Department of Natural Resources 2001*) and information and lists on file at the Atlantic Conservation Data Centre in Sackville.

At sites 20–23, plant association sampling methods were employed following provincial plot standards (Quigley et al. 2005*) and Canadian vegetation classification conventions (CNVC Technical Committee 2004*). In May of 2005, at each of the four sites, a four hundred square meter plot was subjectively placed in a homogeneous tract of heathland vegetation, where canopy tree cover exceeded 10 percent. The sampled association was the open woodland stage of the Annapolis Valley sand plain. Species and cover values, representing percentage of plot area within a vegetation layer, were visually assessed for five life forms (Table 3). Lichen names follow Esslinger (1997*), bryophyte names follow Anderson et al. (1990), and vascular plant names are from Kartesz and Meachum (1999).

Although many voucher specimens were collected (and deposited at DAO), a sufficient number of specimens of the genus *Aronia* were not collected to enable a determination of which species (or hybrid) was present at a particular site. Thus only the genus name appears in Table 2. Although *Rosa carolina* and *Rosa virginiana* were noted, both may have been present at any site where either was recorded, and some intermediates were noted. *Rubus hispidus* may be over-represented in the survey and *Rubus arenicola* may be under-represented due to difficulties in distinguishing these, and hybrids between them may also have been present.

Results and Discussion.

Native species and limitations of the vegetation description

Although 104 native species are recorded from the 23 sites surveyed, and although these sites covered a rather extensive area, they were mostly drier examples of dry, open sandy habitats (Figure 1). The relatively short-lived wetter examples and those associated with natural disturbances, such as fire, are now much less common than the drier examples. Thus as a reconstruc-

TABLE 2: Species abundance and status at 18 heathland sites in the Annapolis Valley. 1 = rare, 2 = uncommon, 3 = common, 4 = frequent and locally dominant, 5 = dominant. * = Introduced. TS = total sites, TC = total cover.

Scientific Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TS	TC
Acer rubrum L.	1	–	2	–	–	1	1	–	1	2	–	–	–	1	2	–	–	–	1	9	12
Achillea millefolium L.	–	–	–	1	–	–	–	1	1	–	1	–	–	–	1	–	1	1	1	8	8
Agrostis tenuis Sibth. *	–	–	–	1	–	–	–	2	2	–	2	1	1	1	–	1	2	–	1	10	14
Amelanchier lucida Fern.	4	4	3	2	–	1	1	2	2	1	2	2	1	–	2	2	1	–	3	16	33
Amelanchier laevis Wieg.	2	2	2	2	2	1	2	2	1	1	2	1	2	–	2	2	1	1	1	18	29
Amelanchier laevis × *lucida*	1	–	–	1	–	–	–	1	1	–	–	–	–	–	–	1	–	–	–	5	5
Anaphalis margaritacea (L.) Benth.	–	–	1	–	–	1	1	1	1	–	–	–	–	1	2	2	1	–	–	9	11
Antennaria howellii ssp. *neodioica* (Greene) Bayer	1	1	–	–	–	–	–	–	–	–	–	2	–	1	–	–	3	–	3	6	11
Apocynum androsaemifolium L. var. *incanum* DC.	1	1	1	1	3	–	1	1	1	–	–	–	–	3	2	–	1	–	–	11	16
Aralia hispida Vent.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	2	2
Arctostaphylos uva-ursi (L.) Spreng.	2	4	1	–	–	–	–	2	5	–	–	–	–	–	2	4	3	2	1	10	26
Aronia sp.	2	3	2	2	2	2	2	1	2	–	1	–	1	–	2	–	–	–	2	13	24
Betula populifolia Marsh	4	5	4	4	–	4	4	1	4	4	4	2	4	2	4	–	2	–	3	16	55
Betula papyrifera	–	–	–	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	2	3
Calamagrostis sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	2	3
Carex deflexa Hornemann var. *deflexa*	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Carex tonsa (Fern.) Bickn. var. *rugosperma* (Mack.) Crins	3	3	3	2	–	1	1	4	3	1	3	3	2	2	2	2	3	3	1	19	42
Carex tonsa (Fern.) Bickn. var. *tonsa*	1	–	1	–	–	–	2	2	–	–	–	–	–	–	–	–	3	1	1	7	11
Carex scoparia Schkuhr	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1
Carex emonsii Dew.	–	–	–	–	–	–	1	–	–	1	–	1	–	–	–	–	–	–	–	3	3
Carex cumulata (Bailey) Mack.	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	4	6
Carex nigra (L.) Reichard	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Centaurea nigra L.*	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	3
Comptonia peregrina (L.) Coult.	3	4	4	2	4	–	2	4	4	3	4	4	3	3	3	3	4	3	2	18	59
Corema conradii (Torr.) Torr. ex Loud.	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5	5	5	5	5	19	91
Cornus canadensis L.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Crataegus cf. *chrysocarpa* Ashe	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1	1	4	4
Crepis tectorum L. *	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Cypripedium acaule Ait.	–	–	1	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	1	4	4
Danthonia spicata (L.) Beauv.	2	3	3	1	2	1	2	3	4	1	2	3	2	3	4	2	4	4	3	19	49
Deschampsia flexuosa (L.) Trin.	4	4	4	3	–	–	3	3	4	–	1	2	2	–	2	–	4	2	3	14	41
Dianthus armeria L. *	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	1	1
Dichanthelium linearifolium (Scribn. ex Nash) Gould	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3	–	1	3	5
Dichanthelium acuminatum var. *fasciculatum* (Torr.) Freckman	1	1	3	–	–	1	1	1	1	1	1	1	1	–	–	–	3	1	1	14	18
Dichanthelium depauperatum (Muhl.) Gould	1	3	3	1	1	2	2	2	2	1	1	1	1	2	2	2	3	1	–	18	31
Diervella lonicera Mill.	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	1	–	–	2	4
Doellingeria umbellata var. *umbellata*	–	–	–	1	–	–	–	–	1	1	–	3	–	–	–	–	–	–	–	4	6
Drosera intermedia Hayne	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	1

TABLE 2. *(continued)* Species abundance and status at 19 heathland sites in the Annapolis Valley. 1 = rare, 2 = uncommon, 3 = common, 4 = frequent and locally dominant, 5 = dominant. * = Introduced. TS = total sites, TC = total cover.

Scientific Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TS	TC
Elymus repens (L.) Gould*	–	–	–	1	–	–	–	1	1	–	–	–	–	–	–	–	2	–	–	4	5
Epigaea repens L.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	2	2
Erigeron strigosus Muhl.	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	2	2	–	3	5
Festuca trachyphylla (Hackel) Krajina *	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Festuca filiformis Pourret *	3	4	3	2	5	–	2	2	3	–	4	4	1	–	3	1	3	3	2	16	45
Fragaria virginiana Duchesne	1	1	–	1	–	1	–	–	–	–	1	–	–	1	–	–	2	–	1	8	9
Gaultheria procumbens L.	1	2	1	1	1	3	2	–	1	4	1	–	1	3	3	–	2	2	2	16	30
Gaylussacia baccata (Wang) K. Koch	2	1	2	2	–	–	–	–	1	1	–	–	1	1	2	–	1	–	1	11	15
Helianthemum canadense (L.) Michx.	1	1	–	–	–	–	–	1	–	–	–	–	–	–	1	–	3	3	–	6	10
Hieracium pilosella L. *	2	4	3	1	4	2	3	4	4	–	3	3	2	3	3	–	4	3	4	17	52
Hieracium piloselloides Vill. *	1	1	3	–	–	–	1	1	1	–	–	–	–	2	–	–	2	1	2	10	15
Hudsonia ericoides L.	4	4	–	4	–	–	2	2	2	–	–	–	2	–	1	3	2	2	3	12	31
Hypericum perforatum L. *	1	2	–	–	–	–	1	2	2	–	1	1	1	1	1	2	1	2	1	14	19
Juncus effusus L.	–	–	1	–	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	3	4
Juniperus communis L. var. *depressa* Pursh	1	2	1	1	3	–	2	–	1	–	–	–	1	1	1	1	1	–	2	13	18
Kalmia angustifolia L.	3	3	1	3	1	3	4	–	2	3	2	1	4	1	–	–	–	–	3	14	33
Lactuca canadensis L. var. *longifolia* (Michx.) Farw.	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1
Larix laricina (DuRoi) K. Koch	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	1
Lechea intermedia Leggett	1	2	1	–	1	1	1	2	3	1	1	3	2	1	1	–	2	1	1	17	25
Leontodon autumnalis L. *	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1
Leucanthemum vulgare Lam. *	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	3	–	4	6
Linaria canadensis (L.) Dumort ?*	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Luzula multiflora (Retz.) Lej.	–	1	–	1	–	1	1	–	–	1	1	1	1	1	–	–	1	–	–	10	10
Lycopodium dendroideum Michx.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Lycopodium tristachyum Pursh	1	1	1	1	–	–	–	–	–	–	–	–	–	2	–	–	1	–	–	6	*
Maianthemum canadense Desf.	–	–	1	–	1	2	1	–	1	1	1	–	1	–	2	–	–	–	1	10	12
Malus pumila P. Mill. *	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Melanpyrum lineare Desr.	2	2	2	1	1	2	2	1	2	1	2	1	2	2	2	–	2	2	2	18	31
Mollugo verticillata L. *	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1
Monotropa hypopithys L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1
Myrica pensylvanica Loisel.	–	–	–	–	1	–	–	1	–	2	–	–	–	3	3	–	2	2	–	7	14
Physalis alkekengi L. *	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Picea glauca (Moench) Voss	1	1	1	1	–	3	2	3	1	4	2	–	3	–	2	2	–	–	–	13	26
Picea mariana (P. Mill.) B.S.P.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	1
Picea rubens Sarg.	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	2	–	–	–	2	5
Pinus resinosa Ait.	4	4	1	5	4	2	3	3	4	–	3	–	4	4	4	3	–	–	2	15	50
Pinus strobus L.	3	4	3	3	1	2	2	5	4	1	3	4	4	3	3	2	1	1	1	19	50
Pinus banksiana Lamb.	–	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	3	3
Pinus sylvestris L. *	5	2	–	3	–	2	–	–	–	1	–	1	–	–	–	–	1	–	1	8	16

TABLE 2. *(continued)* Species abundance and status at 19 heathland sites in the Annapolis Valley. 1 = rare, 2 = uncommon, 3 = common, 4 = frequent and locally dominant, 5 = dominant. * = Introduced. TS = total sites, TC = total cover.

Scientific Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TS	TC
Poa pratensis L.	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	1	1	–	4	4
Poa compressa L. *	1	2	1	–	–	–	–	3	2	–	1	1	–	1	–	2	–	1	–	10	15
Polygonum sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	1
Populus grandidentata Michx.	2	2	2	2	3	3	3	2	3	–	–	2	3	4	3	1	1	1	2	17	39
Populus tremuloides Michx.	3	3	3	2	3	3	3	4	4	–	2	2	3	4	3	3	1	1	1	18	51
Potentilla argentea *	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1
Potentilla canadensis L.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	2
Potentilla recta L. *	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	2	2
Potentilla simplex Michx.	1	1	–	1	–	1	–	–	1	1	–	–	–	–	–	–	–	–	–	6	6
Prunus virginiana L.	1	1	–	1	–	–	–	1	1	–	1	1	1	2	2	2	2	1	2	14	19
Prunus serotina Ehrh.	1	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	1	1	1	6	6
Prunus pensylvanica L. f.	1	4	–	–	–	–	–	1	2	–	1	1	1	1	2	3	–	–	–	10	17
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw.	3	4	5	4	3	4	4	–	1	3	4	4	2	5	3	1	2	2	3	18	57
Quercus rubra L.	1	2	1	1	3	–	2	1	2	4	2	2	2	–	2	1	2	1	2	17	31
Raphanus raphinistrum L. *	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1
Rhododendron canadense (L.) Torr.	2	1	–	2	–	3	2	–	–	1	–	–	3	–	2	–	–	–	2	9	18
Rosa virginiana Mill.	–	–	–	–	–	–	–	2	1	–	–	–	–	–	–	2	1	–	1	5	7
Rosa carolina L.	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	5
Rubus allegheniensis Porter	2	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	2	2	–	5	8
Rubus hispidus L.	3	4	2	2	–	–	1	2	2	3	3	3	3	4	3	1	3	4	1	17	44
Rubus vermontanus Blanch.	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Rubus arenicola Blanch.	1	1	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	3	4
Rudbeckia hirta L. *	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1
Rumex acetosella L.*	2	3	2	2	5	–	2	3	3	1	3	2	1	–	3	–	2	1	1	16	36
Salix humilis Marsh	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	2	2
Sedum acre L.*	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	3
Silene antirhina L. *	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1
Solidago puberula Nutt.	1	1	–	–	–	–	–	–	–	–	–	3	–	–	–	–	1	–	–	4	6
Solidago juncea Ait.	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Solidago canadensis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	2	2
Solidago nemoralis Ait.	–	3	–	–	1	–	–	1	2	–	–	–	–	–	–	–	2	1	2	7	12
Solidago graminifolia (L.) Salisb.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	2	2
Solidago bicolor L.	2	4	1	3	2	2	2	3	2	2	2	2	2	3	3	2	3	3	3	20	46
Spartina pectinata Link	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	1	–	–	1	3
Spiraea alba DuRoi	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	2	–	–	3	4
Spiranthes lacera Raf.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	4	4
Stellaria graminea L. *	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	1
Symphyotrichum lateriflorum (L.) A. & D. Löve	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	2	2
Trientalis borealis Raf.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2	2

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Scientific Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	TS	TC
Trifolium arvense L. *	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	2	–	–	2	3
Trifolium procumbens L. *	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	1
Vaccinium angustifolium × *corymbosum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	1	2
Vaccinium angustifolium Ait.	4	4	4	4	3	5	3	–	4	3	4	3	3	3	4	1	2	2	3	18	56
Vaccinium myrtilloides Michx.	–	–	–	–	–	2	–	1	–	–	–	–	–	1	–	1	–	–	–	4	5
Veronica officinalis L.*	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	–	1	1	–	2	3	–	1	1	1	1	–	1	–	1	–	–	–	1	11	13
Vicia cracca L.*	1	1	–	1	–	–	–	1	1	–	–	–	–	–	1	–	1	1	–	8	8
Vicia tetrasperma (L.) Moench*	1	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	3	3
Viola sagittata Ait. var. *ovata* (Nutt.) T. & G.	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	2	–	–	2	4
Total	126																				
Total Native	94																				
Total Introduced	31																				

tion of the Annapolis sand barren flora, the mesic and successional stages of dry barrens are to a large extent omitted. This may explain the lack of some species in the survey, such as *Agalinis neoscotica* (Greene) Fern. (Middleton False Foxglove), which was described from Annapolis heathlands near Middleton, and also *Bartonia virginica* (L.) BSP., *Carex atlantica*, *Polygala sanguinea* L. and *Sisyrinchium fuscatum* Bickn. All of these species occur on heathlands near Middleton (personal observation), but were not seen during the present survey. Their abundance in the area in the past (Fernald 1921, page 138) suggests that the more mesic and naturally disturbed areas were much more prevalent only a short time ago. Fernald (1921) referred to these as the "the damper Polytrichim-carpeted areas." He noted that "*Bartonia virginica* was everywhere," but it was not recorded in any of the barrens in our survey and only our site 10 approached this damper sand barrens habitat.

In addition to the lack of mesic sites it is of interest that in two days in 1920 Fernald (1921) recorded two species from the drier heathlands near Middleton that were not seen by us. These were *Potentilla tridentata* and *Pyrola rotundifolia*. Although our data indicate the general and dominant composition of the Annapolis heathlands, the differences with Fernald's brief survey suggest that it may never be possible to have a complete knowledge of their former floristc composition.

Dominant vascular plants

Relatively few of the 126 species (94 were native and 31 introduced – Table 2) present in the 19 completely surveyed sites were dominant in the vegetation. Species present at all sites included *Corema conradii*, *Danthonia spicata*, *Pinus strobus* and *Solidago bicolor*. Species present at 18 of the 19 sites were *Amelanchier laevis*, *Carex tonsa* var. *rugosperma*, *Comptonia peregina*, *Dichanthelium depauperatum*, *Pteridium aquilinum* var. *latiusculum*, *Vaccinium angustifolium* and *Populus tremuloides*. Species with the highest overall cover values included *Corema conradii* with 91 followed by *Comptonia peregrina* with 59, *Pteridium acquilinum* var. *latiusculum* with 57, and *Vaccinium angustifolium* with 56. A number of species, including *Solidago bicolor, Carex tonsa* var. *rugosperma*, *Dichanthelium depauperatum*, *Lechea intermedia*, *Melampyrum lineare* and *Rubus hispidus*, were characteristic of heathland remnants, although they were rarely dominant. The most frequent alien species were *Hieracium pilosella* and *Festuca filiformis*, both at 17 and 16 (respectively) of 19 sites. The most serious invasive of the heathlands in terms of displacing native species was *Pinus sylvestris*, present at 8 sites (Catling and Carbyn 2004).

The more wooded plot sites (20–23) gave a very similar picture of the *Corema*-dominated heathland, but with scattered trees, mostly *Pinus resinosa* (Table 3, Figure 3). Three species more often associated with woodland than with barrens (*Clintonia borealis*, *Lyco-*

TABLE 3. Cover values for vegetation layers in single 400 square meter plots at each of 4 sites in the Annapolis valley, based on data collected by Sean Basquill in May 2005. * = introduced, + = not listed in Table 2.

Species	Site 20	Site 21	Site 22	Site 23
Trees				
Amelanchier laevis Wieg.	2	–	–	–
Betula populifolia Marsh	3	2	5	5
Picea mariana (P. Mill.) B.S.P.	–	–	5	–
Pinus resinosa Ait.	20	25	20	10
Pinus strobus L.	–	–	5	8
Pinus sylvestris L. *	–	–	–	10
Prunus pensylvanica L. f.	–	1	–	–
Quercus rubra L.	–	4	0.1	–
Shrubs and small trees				
Amelanchier laevis Wieg.	–	–	0.1	0.2
Betula populifolia Marsh	3	2	5.1	3
Comptonia peregrina (L.) Coult.	1	1	–	–
Juniperus communis L. var. *depressa* Pursh	–	–	–	0.1
Picea mariana (P. Mill.) B.S.P.	–	0.1	–	–
Pinus resinosa Ait.	4	4	1	1
Pinus strobus L.	0.5	–	1	5
Pinus sylvestris L. *	–	–	–	5
Quercus rubra L.	–	1	–	–
Vaccinium angustifolium Ait.	0.1	0.5	3	6
Herbs and dwarf shrubs				
Arctostaphylos uva-ursi (L.) Spreng.	30	5	10	8
Betula populifolia Marsh	–	–	0.2	–
Carex tonsa (Fern.) Bickn. (sensu lato)	0.01	0.1	1	1
Clintonia borealis (Ait.) Raf. +	–	–	0.01	–
Corema conradii (Torr.) Torr. ex Loud.	58	40	60	60
Deschampsia flexuosa (L.) Trin.	–	–	1	1
Dichanthelium depauperatum (Muhl.) Gould	–	–	0.1	–
Epigaea repens L.	–	–	0.01	0.1
Festuca filiformis Pourret *	0.1	–	0.01	0.5
Festuca trachyphylla (Hackel) Krajina *	–	0.001	–	–
Gaultheria procumbens L.	0.5	0.01	–	–
Hieracium piloselloides Vill. *	–	–	0.01	–
Hudsonia ericoides L.	0.01	0.1	–	0.3
Kalmia angustifolia L.	0.1	0.01	–	–
Lechea intermedia Leggett	0.001	–	–	–
Lycopodium obscurum L. +	–	–	0.1	–
Lycopodium tristachyum Pursh	0.1	0.01	–	–
Maianthemum canadense Desf.	–	–	0.01	–
Oryzopsis asperifolia Michx. +	–	0.1	0.2	–
Poa pratensis L.	–	0.1	0.1	0.1
Potentilla simplex Michx.	–	–	–	0.2
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw.	10	1	0.02	–
Rubus hispidus L.	–	0.001	–	0.01
Solidago bicolor L.	–	0.2	–	–
Solidago nemoralis Ait.	–	0.001	0.2	0.1
Taraxacum officinale G. H. Weber *ex* Wiggers	–	–	0.002	–
Trientalis borealis Raf.	0.01	–	0.01	–
Vaccinium angustifolium Ait.	–	–	–	0.01
Mosses				
Ceratodon purpureus (Hedw.) Brid.+	–	0.001	–	2
Dicranum scoparium Hedw.+	–	1	–	–
Pleurozium schreberi (Brid.) Mitt.+	0.5	0.1	0.5	–
Polytrichum commune Hedw.+	–	–	0.1	1
Polytrichum juniperinum Hedw.+	–	0.01	0.3	3
Lichens				
Cladina rangiferina (L.) Nyl.+	18	40	7	10
Cladina stellaris (Opiz) Brodo +	2	10	3	5

FIGURE 3. Open wooded heathland dominated by *Corema conradii* and *Cladina rangiferina* with scattered *Pinus resinosa*. Although there is much open area, the site exceeds the threshold 10% tree cover required for classification as a treed association under Canadian vegetation classification conventions (CNVC Technical Committee 2004*). Photo by S. Basquill on 25 May 2005 at site 20.

podium obscurum and *Oryzopsis asperifolia*) were present a these more wooded sites. Although vascular plants were the focus of the descriptive work, the plot data included lichens and bryophytes, suggesting the former (*Cladina rangiferina* and *C. stellaris*) to be a significant component. This suggestion is supported by general observations at the 19 other sites where quantitative data on bryophytes and lichens was not obtained.

Although Roland (1946) described the Annapolis sand barrens and heathlands 60 years ago, his description, which recorded 35 species, corresponds very closely to the composition seen in the relicts that remain today. The successional processes are possibly also the same as described generally by Roland, but succession may have been much more rapid in some areas than in others where barrens and heathlands may have existed as a subclimax lasting for centuries, even without fire. Roland's article was written at a time when sand barrens, heathlands and savanna were regarded as wasteland rather than as special places for native biodiversity, but his strong forestry theme is accompanied by many astute observations regarding the native flora. At the time of early settlement the barrens and heathlands may have expanded due to cutting and burning of pine forests and abandonment of sandy land cleared for agriculture as suggested by Roland. However there is little doubt that they also existed in pre-settlement times.

Rare and significant species

The only species considered to be at risk in Nova Scotia that occurs in the Annapolis heathlands is *Helianthemum canadense* (Long-Branch Frostweed, Figure 4). It was found at 6 of the sites, always in disturbed habitats with some bare sand. Both *Viola sagittata* var. *ovata* and *Hudsonia ericoides* are listed as sensitive (Nova Scotia Department of Natural Resources 2001*), and these also occurred in disturbed sandy areas (Figure 5). The provincially rare (Maher et al. 1978) *Sisyrinchium fuscatum* Bickn. (Coastal-Plain Blue-Eyed-Grass) was reported from "sandy areas near Middleton" (*sub Sisyrinchium arenicola* Bickn., Roland and Smith 1969), but was not seen during the present survey.

In addition to the rare and threatened species there is a suggestion of some distinctive patterns of variation due to taxonomic recognition of several variants. Among these is a sand barren ecotype of *Amelanchier lucida* (personal observation). Taxa of blackberries (*Rubus particeps, R. arenicola*), although not recognized as discrete in some recent literature, have been reported from the Annapolis heathlands suggesting at

least the presence of distinctive genetic variants within broadly defined species. Further study may indicate both of these to be worthy of taxonomic recognition. A restricted glabrous variant of *Viola sagittata* var. *ovata* (f. *glabrata*) occurs on the dry open sand with the more typical form. Three taxa have been described from Annapolis heathlands: *Amelanchier lucida* Fernald, *Dichanthelium (sub Panicum) depauperatum* var. *psilophyllum* f. *cryptostachys* Fernald, and *Rubus particeps* Bailey.

The heathland ecosystem is particularly valuable as a reservoir of genetic variation in crops and crop relatives. Fernald (1921) commented on the remarkable variation in wild blueberries (*Vaccinium angustifolium* and *V. myrtilloides*) in Annapolis heathland remnants near Middleton. In addition to blueberries (Table 2) there are potential genotypes of Aronia (*Aronia* sp.), of blackberries (*Rubus hispidus* and others), juneberries (*Amelanchier lucida* and *A. laevis*), huckleberries (*Gaylussacia baccata* and *G. dumosa*), cherries (*Prunus pensylvanica*, *P. virginiana*, and *P. serotina*) and a strawberry (*Fragaria virginiana*).

Variation between sites

Although all sites shared dominant species (Table 2) they varied in diversity from 26 to 57 native species. Much of the variation between sites appeared to be attributable to disturbance and soil moisture. Those sites with lower lying and periodic moist areas and open sand had the highest vascular plant diversity. Site 10 for example was the most unlike the other sites in native species composition, possibly a result of parts of it having a relatively high water table and disturbed areas of periodically moist sand where dry ground species such as *Carex tonsa* var. *rugosperma* and *Danthonia spicata* occurred with wetland species such as *Drosera intermedia*.

Characteristic native species and "at risk" or "sensitive" species were present at some sites but absent from others (Table 2). Sites also varied in the extent to which alien species were present and dominant (Table 2). For example parts of sites 1 and 4 had extensive and spreading stands of *Pinus sylvestris*, but displacement of native vegetation by this introduced tree was either less extensive or not observed at other sites. *Festuca filiformis* was a co-dominant at site 5 but not elsewhere.

Species presence, diversity and extent of impacts all require consideration in selecting sites for protection. The variation between sites in composition and abundance, including that of rare and/or characteristic species, suggests that protection of a number of sites will be necessary to protect representative ecosystem components.

Relationship to other heathlands and barrens

In Canada, *Corema*-dominated barrens are characteristic of the maritime region. *Corema conradii* has a restricted distribution extending from the Gulf of St. Lawrence region south to New Jersey. It does not occur in sand barrens further to the west in Canada, for example in the Ottawa valley, where *Vaccinium angustifolium* is the dominant heath shrub accompanied by other shrubs such as *Prunus susquehanae* and *Comptonia peregina* (Carbyn and Catling 1995). Other species present in the Annapolis heathlands but absent in Ottawa valley sites were *Amelanchier lucida, Deschampsia flexuosa, Rubus hispidus* and *Solidago bicolor*. Among the prevalent species in Ottawa valley sand barrens but absent in the Annapolis sites were *Carex siccata, Carex lucorum, Dichanthelium sabulorum* var. *thinium, Polygonella articulata* and *Prunus susquehanae* (Carbyn and Catling 1995).

FIGURE 4. *Helianthemum canadense* (Long-Branch Frostweed), a native plant at risk in Nova Scotia, with its main Nova Scotian occurrence on the Annapolis valley heathlands. Photo by P. M. Catling in 2004 at site 8.

Within Nova Scotia, "barrens" with heath vegetation occupied a large part of the western portion of the province (Strang 1972). Some of these barrens are a short-lived successional stage following fire, whereas in other cases they are long persisting. Those of short duration have in some cases been produced by cutting and then maintained by fires. Two such barrens were described by Hall and Aalders (1968). Such barrens, produced by human activities, have been considered a degraded landscape of little economic value. The existence and importance of apparently natural barrens have only recently become apparent (Catling et al. 2004). The sites described by Hall and Aalders (1968) differ from those in the Annapolis Valley in lacking *Corema conradii*, the dominant of the Annapolis barrens. They were also without several other species, including *Hudsonia ericoides*. On this basis the differences between man-made and natural barrens seem

FIGURE 5. Open sandy ground in a disturbed area of heathland with *Comptonia peregrina* (Sweet Fern) and *Viola sagittata* var. *ovata* (Arrow-leaved Violet). Photo by P. M. Catling in 2004 at site 8.

pronounced, but with only two anthropogenic sites, a more detailed comparison is unnecessary.

The apparently longer persisting natural barrens in Nova Scotia are readily divided into two major vegetation types based on either granitic or sandy substrates (personal observation). Sandy heathlands like those of the Annapolis Valley were also well developed in the interior of Yarmouth County and near Debert, Springhill, Parrsboro, and on coastal dunes in Guysborough and Kings counties and on Sable Island. The coastal heathlands on sand differ from the interior sites in both species composition and species abundance, and the differences suggest adaptation to different conditions. Differences also exist at the infraspecific level. For example *Lechea intermedia* var. *intermedia* occurs in interior heathlands while *L. intermedia* var. *juniperina* occurs on the coastal sandy heathlands. The heathlands on Sable Island appear distinct (Catling et al. 1985). The interior sandy heathlands also appear to vary regionally, presumably due to differences in climate. The climate in southern Yarmouth and Shelburne differs from that of the Annapolis Valley (personal observation). The data suggest that the Annapolis heathlands are distinctive in their floristic composition.

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Pacific Hagfish, *Eptatretus stoutii*, Spotted Ratfish, *Hydrolagus colliei*, and Scavenger Activity on Tethered Carrion in Subtidal Benthic Communities off Western Vancouver Island

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Davies, Sarah, Ali Griffiths, and T. E. Reimchen. 2006. Pacific Hagfish, *Eptatretus stoutii*, Spotted Ratfish, *Hydrolagus colliei*, and scavenger activity on tethered carrion in subtidal benthic communities off Western Vancouver Island. Canadian Field-Naturalist 120(3): 363–366.

The influence of pelagic carrion food falls on marine benthic scavenging communities was investigated at two depths (10 m, 50 m) in Barkley Sound, west Vancouver Island, British Columbia from 12 May to 4 June, 2003. A remotely operated vehicle (ROV) equipped with video cameras was used to monitor anchored carrion (15 kg pig leg) during daylight and darkness. The videos were subsequently analyzed for species diversity, abundance and the intensity of scavenging. At 10 m, Redrock Crab (*Cancer productus)* and Kelp Greenling (*Hexagrammos decagrammus)* dominated, while at 50 m, Spot Shrimp (*Pandalus platyceros),* Spotted Ratfish (*Hydrolagus colliei)* and Pacific Hagfish (*Eptatretus stoutii)* were the dominant species, most of which were nocturnal. Hagfish were the major consumers of the carrion and after 23 days, no soft tissues remained at 50 m while 40% remained at 10 m. Within 24 hours of the carrion deployment, two of eleven ratfish succumbed, probably due to the direct clogging effects of hagfish mucus on the respiratory apparatus of the ratfish. These field observations are consistent with laboratory results suggesting high efficacy of hagfish mucus in competitive interactions.

Key Words: Pacific Hagfish, *Eptatretus stoutii,* Spotted Ratfish, *Hydrolagus colliei,* Spot Shrimp, *Pandalus platyceros,* Redrock Crab, *Cancer productus,* Kelp Greenling, *Hexagrammos decagrammus,* marine scavengers, carrion, remotely operated vehicle (ROV), nutrient cycling, Vancouver Island, British Columbia.

Vertebrate carcasses provide an episodic but highly important food source for benthic organisms, particularly at depths beyond the zones of primary productivity (Lalli and Parsons 2001). Such carcasses have recently become of interest due to increasing discards in fisheries as this may shift benthic community structure (Collins et al. 1999). Species such as ratfish and benthic sharks as well as crustaceans may benefit from such food falls (Collins et al. 1999; Tamburri and Barry 1999). There are few descriptions of the scavenging community or the interactions among species around these carcasses.

We anchored carrion at two depths (10 m, 50 m) in Barkley Sound, west Vancouver Island, British Columbia and monitored the carrion with a remotely-operated vehicle (ROV). We provide here an examination of scavenger diversity, abundance and interactions among species during daylight and darkness.

Methods

Two soft-substrate sites (10 m, 50 m: 48°50'N, 125°10'W) in Mackenzie Anchorage, Barkley Sound, British Columbia were chosen and single 15 kg pig legs (frozen with intact skin) were anchored at each site. Initial deployment occurred at 1030 h on 12 May 2003. An ROV (Deep Ocean Engineering Phantom HD2+) equipped with 5mW 635 nm lasers (10 cm standard for scaling) and 250W Tungsten-Halogen lights were used to monitor the carrion. The ROV was stationed beside the carrion for 30 minutes during night trials and 15 minutes (due to less activity) during day trials. We switched the ROV lights off for 1-2 minutes on several occasions during the night monitoring phase but observed no changes in activity. Before surfacing with the ROV, areas within 5 m of carrion were scanned for individuals. Day trials of the ROV were carried out near 1400 h and replicated on three occasions (13, 14, 16 May) while night trials occurred near 2230 h and were replicated on four occasions (12, 13, 14, 23 May). The experiment was terminated on 4 June and the two carcasses returned to the surface and relative tissues were estimated. Twelve hours of videotape were analyzed. Percent of remaining carrion and sizes of scavengers were estimated from the laser standards. Species were identified and all individuals within several metres of the carrion were counted. General behavior of the species was noted. Paired sampled t-tests were used to test for significant differences for species and abundance between sites and within sites.

Results

Species Abundance

Carrion anchored at the two depths attracted a different assemblage of species (Figure 1). At 10 m, Redrock Crab (*Cancer productus)* (7-20 cm), and Kelp Greenling (*Hexagrammos decagrammus)* (11-23 cm)

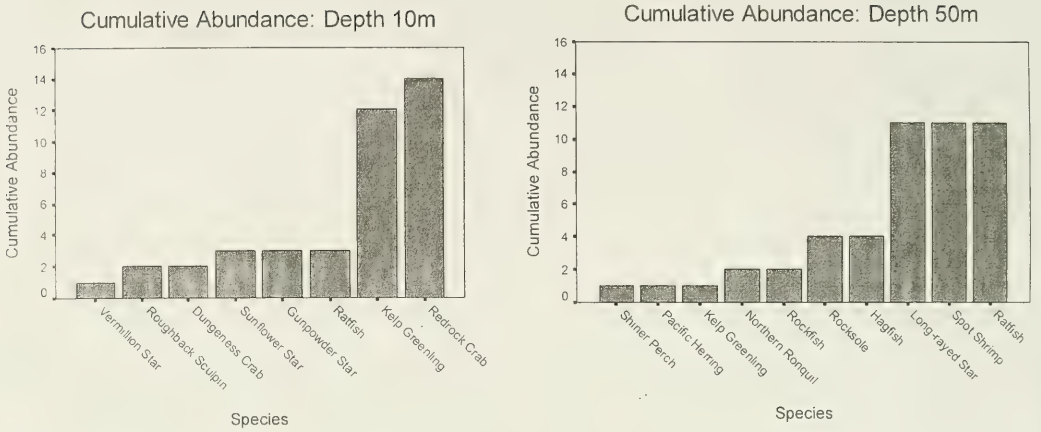

FIGURE 1. Cumulative species abundances of scavengers observed at carrion anchored at 10 m and 50 m in Barkley Sound, Vancouver Island.

were the dominant species, while at 50 m, Long-rayed Star (*Stylasterias forriei)* (20-60 cm), Spot Shrimp (*Pandalus platyceros)* (12-20 cm), Spotted Ratfish (*Hydrolagus colliei)* (18-25 cm), Pacific Hagfish (35-65 cm) and Rocksole *(Lepidosetta bilineata)* were dominant. Only two of 16 species (Spotted Ratfish, Kelp Greenling) were common to both sites (Figure 2). Although all species were in direct contact or immediately adjacent to the carrion, only six species actively foraged off the carrion (Pacific Hagfish, Redrock Crab, Dungeness Crab (*Cancer magister*), Sunflower Star (*Pycnopodia helianthoides)*, Long-rayed Star (*Orthasterias koehleri)*, and Spot Shrimp). Hagfish undertook extensive burrowing and excavations and were the major consumers of tissues. Ratfish swam commonly in close vicinity to the carrion but we observed no foraging activity. Daily consumption rates at 10 m were initially high and then decreased while at the 50 m site, the rate increased throughout the duration of sampling. On the last ROV survey (Day 23), 40% of the soft tissues remained at the 10 m site while only bone remained at the 50 m site.

Diel variations

The scavenger community differed during daylight and darkness (Figure 3). At both sites there were increased numbers of species observed during darkness (10 m Day, 5 , Night, 11; 50 m Day, 5, Night, 9). At 10 m depth, nocturnal scavengers were Redrock Crab, Spotted Ratfish, Roughback Sculpin (*Chitonotus pugetensis)*, and Dungeness Crab. At 50 m, Long rayed Star was present in both day and night trials and was seen continually in all surveys. Northern Ronquil (*Ronquilus jordani)*, Rocksole and Kelp Greenling were seen only during day trials. Pacific Hagfish, Spotted Ratfish, and Spot Shrimp were dominant at night.

Behavioural interactions within and among scavenger species

Diverse interactions occurred among species. Redrock Crabs defended the carrion by direct attacks against conspecifics as well as against Kelp Greenling. Pacific Hagfish excavated burrows within the carrion by rasping, full-body spinning and occasional knotting. Spotted Ratfish swam in close vicinity to the carrion and in several instances directly contacted the hagfish but we saw no evidence of agonistic behaviour. However, during the second ROV flight, we observed two freshly deceased ratfish lying within several meters of the carrion. There was no evidence of external damage to either ratfish but there was extensive subsurface haemorrhaging around the mouth on one ratfish and strands of mucus on the second and we infer rapid respiratory failure from the hagfish mucus that was prevalent in the water column around the carrion. During the ROV survey, hagfish did not feed on dead ratfish. Strands of mucus that separated from hagfish when feeding on the carrion were very adhesive as the strands disabled thruster motors of the ROV.

Discussion

High productivity and the recycling of nutrients sustain large populations of benthic organisms in the waters of the continental shelf (Nybakken 2001). We examined an experimental food fall at two (10 m, 50 m) natural habitats in coastal British Columbia and found that species assemblages differed between depths and with diel variation. The intensity of scavenging was greater at increased depth and increased during night, which corroborates well with other observations on scavenging communities (Collins et al. 1999). Shifts in diel patterns to nocturnal activity are common in marine

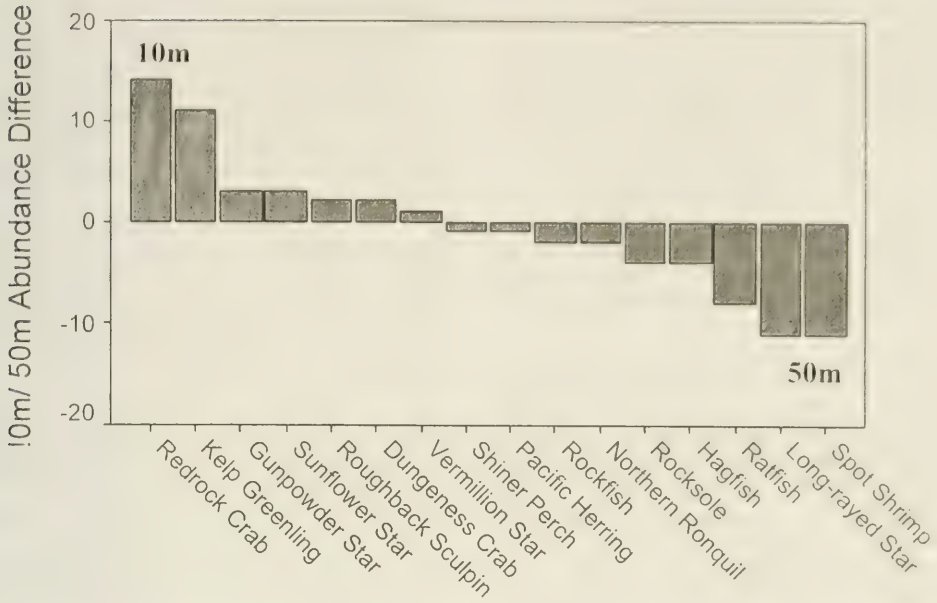

FIGURE 2. Relational abundance of scavenger species at carrion anchored at 10 m and 50 m depth (number of individuals at 10 m – number of individuals at 50 m depth), Barkley Sound. Positive values show greater occurrence at 10 m depth. Negative values show greater occurrence at 50 m depth.

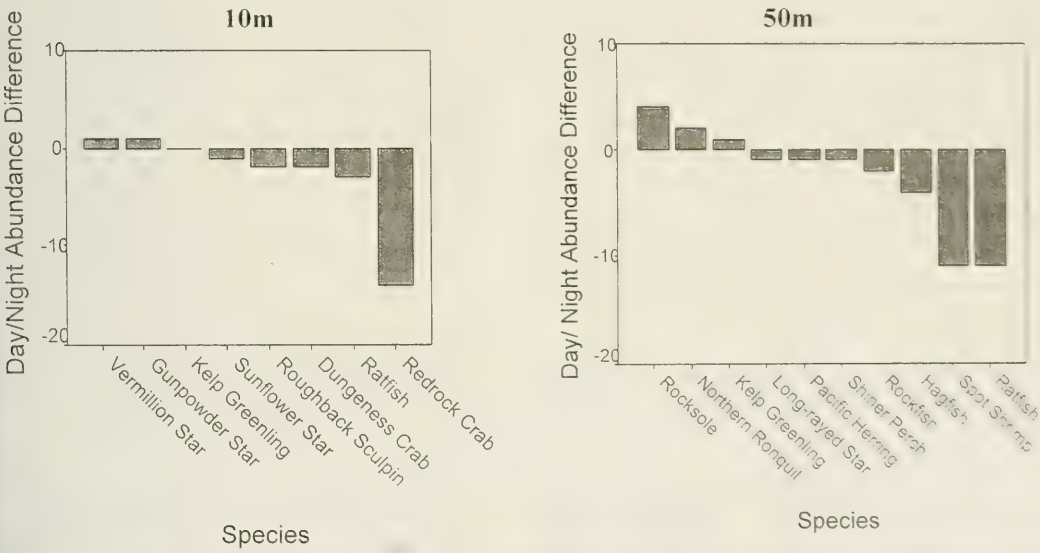

FIGURE 3. Relational abundance of scavenger species due to diel variation (number of individuals during daylight – number of individuals during night). Positive values show greater occurrence during daylight. Negative values show greater occurrence during night.

benthic habitats (Lalli and Parsons 2001) and may reflect predator avoidance or reduction in competition. The agonistic encounters observed among crabs and fish indicate that carrion represents significant local energy enrichment to the benthic community (Stockton and DeLaca 1982).

Spotted Hagfish were the major scavengers at 50 m and were largely nocturnal, consistent with the findings of Fernholm (1974). These fish play an important role in the turnover and cycling of nutrients (Lesser et al. 1996; Collins et al. 1999). We observed a much higher rate of tissue loss at the 50 m site where hagfish

were prevalent. Since hagfish are dependent on food falls, specialized adaptations to minimize competition are present. Knotting is considered to be an important feeding behavior in which the hagfish attaches to prey with tooth plates and passes a knot from the caudal region anterior towards the head allowing tissues to be ripped off (Collins et al. 1999). We also observed this behavior, but only on a single occasion. Rather, hagfish primarily used full body spinning to pull pieces of tissue from the carrion. Such full body rotation is also present in sharks feeding on large prey and may allow an increase in their effective gape (Helfman et al. 1997).

Hagfish produce copious amounts of slime when feeding, agitated or threatened (Strahan 1963; Tamburri and Barry 1999). There are probably diverse functions to this slime including burrowing, defense and competitive exclusion (Collins et al. 1999). Hagfish burrowed into the carcass up to ¾ of their total body length. While the mucus may facilitate entry into the carrion, the burrowing would also cover the gills and this would limit gas exchange of the hagfish. This suggests the potential for posterior cutaneous respiration. Lesser et al. (1996) noted that hagfish skin was well-vascularized and hagfish are therefore able to survive with plugged nostrils and no respiratory current across the gills. Slime produced by hagfish has high strength (Fudge et al. 2003) and can also obstruct mouthparts and gills of other species attempting to feed at food falls (Tamburri and Barry 1999; Collins et al. 1999). Our ROV observations are consistent with these suggestions. Two of the ratfish swimming in close proximity to the foraging hagfish quickly succumbed, presumably from loss of respiratory ability. The close proximity suggests high efficacy and rapid effects of the hagfish mucus in natural conditions even under high dilution effects. If these observations are representative, it suggests that hagfish may not only have a substantial competitive advantage over other fish species in these episodic carrion fallouts but also operate as predators through the lethal influences of mucus on other scavengers.

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Notes

A New Record Size Wolf, *Canis lupus*, Group for Ontario

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Vors, Liv S. and Philip L. Wilson. 2006. A New Record Size Wolf (*Canis lupus*) Group for Ontario. Canadian Field-Naturalist 120(3): 367–369.

This report documents a group of 19 Wolves (*Canis lupus*) in northwestern Ontario. This is the largest group observed since record keeping in the Moose Aerial Inventory commenced in 1995. This large group may be a response to a high Moose (*Alces alces*) population in the Red Lake area.

Key Words: Gray Wolf, *Canis lupus*, social organization, pack size, Moose, *Alces alces*, Ontario.

The close association between Gray Wolves (*Canis lupus*) and their ungulate prey greatly influences the ecology of this cursorial predator, which is capable of killing prey much larger than itself (Kolenosky and Standfield 1975). Pack size is believed to be influenced by numerous factors. Pack sizes do not necessarily differ among Wolf populations whose major prey species are different. For example, average sizes of Wolf packs mainly depredating on Moose (*Alces alces*) are not necessarily larger than those feeding on White-tailed Deer (*Odocoileus virginianus*), but Wolf packs tend to be largest where Wolves prey on the largest ungulates (Fuller et al. 2003). This note documents one large group of Wolves observed in Ontario, Canada.

Observation

A group of 19 wolves was observed on 15 February 2005 between 1300 and 1400 hours on a frozen lake west of the settlement of Red Lake, Ontario, at approximately 51°05N and 94°05W. Red Lake (51°04N, 93°47W) is a settlement located in the boreal forest of northwestern Ontario. This sighting took place during a transect flight to map areas of Woodland Caribou (*Rangifer tarandus caribou*) habitat activity. The aircraft, a De Havilland Turbo Beaver, was flying at a speed of 90 knots and an altitude of 400 feet when the group was observed. Ontario Ministry of Natural Resources (OMNR) pilot Carl Hansson, Trent University graduate student Liv Vors, Sir Sanford Fleming College Fish and Wildlife Technologist graduate Philip Wilson, and Red Lake OMNR employee Claire Quewezence observed and counted the Wolves.

The aircraft made several circles over the animals, which were loosely congregated near the western shore of the lake. The Wolves ran around the ice, evidently disturbed by the aircraft, but made no attempts to flee into the neighbouring forest. No kill was visible. The animals were counted and confirmed by all observers. After about two minutes of observation, the aircraft resumed its transect flight.

Discussion

We believe this group to be the largest on record for Ontario, and possibly all of Canada east of the Rocky

Table 1. Records of maximum Canadian Wolf pack sizes west of the Rocky mountains, 1969-2005.

Location	Size	Source
Riding Mountain National Park, Manitoba	16	Carbyn (1980)
Jasper National Park, Alberta	14	Carbyn (1974)
Southeastern Quebec	10	Potvin (1988)
Northwestern Alberta	10	Bjorge and Gunson (1985)
Algonquin Provincial Park, Ontario	9	K. Mills, personal communication, 2005
Southwestern Quebec	8	Messier (1985)
Parry Sound Forest District, Ontario	8	Kolenosky (1972)
Pukaskwa National Park, Ontario	6	Forshner (2000)

Mountains. Wolf pack records are kept in the Moose Aerial Inventory Database 1995–2006*. Before this sighting the largest pack on record was 13, and was sighted in WMU (Wildlife Management Unit) 15A in 1998. Reported average pack sizes in Ontario range from 3.8 (Bergerud et al. 1983) to 5.9 (Pimlott et al. 1969) to 6.0 (Forbes and Theberge 1996), with maximums of 7, 9 and 13, respectively. Our observation of 19 wolves is significantly higher than most packs reported in Canada (Table 1).

Gray Wolves found in the North American landscape represented in their northern Ontario range predominantly prey upon ungulates and Beaver (*Castor canadensis*) (Carbyn 1987; Gauthier and Theberge 1987). Large packs likely provide increased hunting efficiency when prey is scarce, or may alternatively be a response to abundant prey (Schmidt and Mech 1997). We suggest the large group we observed is a response to the latter. Since 1975, Moose populations in the Red Lake area have increased from a density of 0.059-0.209 animals/km^2 to 0.359-0.509 animals/km^2 (McKenney et al. 1998). Current Moose densities in the Red Lake area are lower than McKenney's estimates. Moose in the Red Lake WMU were estimated to be 0.265 animals/km^2 in 2004 (unpublished data, Ontario Ministry of Natural Resources, Bracebridge, Ontario). White-tailed Deer are also expanding their range northward, providing additional prey (Red Lake OMNR, personal communication). Wolf density is positively correlated with ungulate numbers (Fuller 1989; Messier 1994). Although Moose density has declined since 1998, the ungulate biomass may still be high enough to support a large Wolf population.

The relationship between pack size and prey size, however, is imperfectly understood. While food acquired per Wolf may be positively correlated with pack size (Nudds 1978), this relationship is not consistent. A review of prey use by Wolves in several geographic areas suggested a negative relationship between pack size and food acquisition (Schmidt and Mech 1997). In addition, prey size and pack size may not be closely linked. Mech (2000) observed a pack of 22-23 wolves in Minnesota, and this group preyed primarily on White-tailed Deer. Consequently, prey size and food acquisition are unlikely to be the only factors explaining the large group we observed. An additional caveat is the group we observed may have consisted of several packs that converged at the time of observation.

An additional point of interest was the colour of the wolves. All were dark brown or black, with the exception of one silvery-white individual. Most wolves in eastern Canada are gray, with black and white individuals constituting approximately four and less than one per cent of the population, respectively (Gipson et al. 2002).

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A Tribute to Nicholas Stephen Novakowski 1925–2004

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Nicholas Stephen Novakowski was an enthusiastic and very knowledgeable wildlife and fisheries scientist. Although his list of published works is modest, he was well known and respected across Canada and in several international fora. He has been credited as "the person who saved the Wood Bison as a discrete subspecies" (W. E. Stevens, personal communication) and was highly engaged in the early years of the surveys and recovery of the Whooping Crane (Novakowski, 1965b, 1966). Following those early days at Fort Smith, North West Territories, Nick was transferred first to the Edmonton office of the Canadian Wildlife Service and then to CWS headquarters in Ottawa where he was appointed Staff Specialist, Mammalogy, and took on national and international responsibilities. He retired in 1983 but continued his strong support for endangered wildlife and their habitats until his death on 3 July 2004 in Ottawa. He is survived by his wife, Amy, and two sons, Kent, a professor of hydrogeology and environmental engineering at Queen's University and Erin Nicholas, a professor of geography and environmental studies at Memorial University.

Nick was born 28 November 1925 in Mundare, Alberta (about 70 km east of Edmonton), the second child and eldest son in a family of 10 children. His father owned a Chrysler dealership and garage and from an early age Nick learned about all things mechanical – a fact that would stand him in good stead in later years as a field biologist. He also developed an abiding loyalty to Chrysler products and, briefly, owned only one automobile that didn't bear that company's mark. Finding the alternate car highly unreliable, he soon returned to his original choice and did not waver again. In his younger years he was a superb athlete. He and his brothers Archie and Van were well known in central Alberta hockey circles as a high-scoring powerhouse. Nick, who was ambidextrous, could play either wing and was a sharp goal tender (Ken Novakowski, personal communication). Also in those early years he became an ardent angler and as often as possible visited members of his extended family who lived in towns north of Edmonton. One of his favourite spots was Siebert Lake. Just a couple of weeks before his death he very happily returned there with his sister, Sharon, and her husband to renew those earlier experiences – with considerable success. Time had not dulled his expertise.

Nick entered the University of Alberta in 1947 and in the following two summers worked on forest fire suppression crews based in Fort Smith, North West Territories. There he became acquainted with Bill Fuller, the resident mammalogist for the Canadian Wildlife Service. He graduated with a B.Sc. in Chemistry in 1950 and that summer returned north but this time he was hired by Northern Transportation Company Limited (NTCL) for summer work on the docks at the company's shipping base near Fort Smith. At that time NTCL gave hiring priority to young men who could enhance its baseball team and Nick "was a very good ball player" (W. A. Fuller, personal communication). Nick returned to the University of Alberta that autumn to begin a Master's program and went back to Fort Smith in the spring of 1951. That autumn Dr. Fuller was assigned to conduct research of Wolves in Wood Buffalo National Park (WBNP) and adjacent areas of the Mackenzie District and employed Nick as an assistant (see Fuller and Novakowski 1955). Nick also helped Fuller with his studies of Beaver and with the "autopsies of lone, crippled, bison we encountered from time to time" (W. A. Fuller, personal communication). It was the start of Nick's wildlife and fisheries career, and perhaps of equal importance, the start of the romance that led in June 1952 to his marriage to the love of his life, Amy Swartz, a Fort Smith school teacher from Saskatchewan.

Also in 1952, with Fuller's recommendation, Dr. D. S. Rawson accepted Nick for graduate studies in fisheries at the University of Saskatchewan. Over the next few years he worked very happily at his studies and as a fisheries biologist for the Government of Saskatchewan. Although only one published paper appears to have resulted from that work (Atton and Novakowski 1956), he authored or co-authored many in-house reports for the Saskatchewan government dealing with fisheries research and resource management. Amy Novakowski tells me that those were the happiest years of Nick's life – helped, no doubt, by the fact that Amy was able to accompany him on many of his extended field studies in northern Saskatchewan. The photograph accompanying this article was taken at that time.

After completing his M.Sc., (Novakowski 1955c*) Nick was hired by the Canadian Wildlife Service in 1956 and sent to Fort Smith. His mentor, Dr. Fuller, was transferred that year to Whitehorse, Yukon, and Nick dived immediately into Dr. Fuller's continuing studies of Beaver populations in the southwestern Northwest Territories, Wolves in Keewatin District (Flook and

FIGURE 1. Nick Novakowski, fisheries researcher, Lac des Iles, Saskatchewan, 1955.

Novakowski 1956*; see also Novakowski 2003) and Bison and Whooping Cranes in Wood Buffalo National Park.

In 1957, in the course of an aerial survey of Bison in WBNP, he discovered the presence of an isolated herd of Bison in the Nyarling River area in the northwest corner of the Park (Banfield and Novakowski 1960). Subsequent aerial and ground studies indicated that the herd might be Wood Bison genetically uncontaminated by the Prairie Bison that had been transferred to WBNP in the 1920s. In 1959, Nick was able to obtain specimens which were confirmed by the National Museum to be Wood Bison (Banfield and Novakowski 1960). In the following three years he arranged for over 70 live specimens to be trapped and tested for tuberculosis and brucellosis. Of those, 18 that were disease-free were moved in February 1963 to a large holding corral northwest of Fort Smith. Three calves arrived that spring and in early summer all of the animals were again tested for disease. All were clear. Nick had previously scouted out appropriate habitat north of Fort Providence, North West Territories (Novakowski, 1959d*), and 18 disease-free Wood Bison, including the new calves, were transported there in August 1963. That area, now known as the Mackenzie Bison Sanctuary, proved to be an excellent site and the small nucleus soon swelled. Subsequently other specimens were taken from the Nyarling River site, transferred to Elk Island National Park, and after a rigorous clean-up protocol, produced another disease-free herd of Wood Bison (Gates et al. 2001). Some of Nick's less well-known Bison research included "the first use of dental annuli to estimate the age of bison" (Christianson et al. 2005). The same authors also credit him with being the first to measure and to demonstrate the usefulness of other Bison dentition measurements in aging large samples.

In 1958, Nick was also in charge of stocking Pine Lake and a few smaller lakes in WBNP with Rainbow Trout. He established and operated a small hatchery for that purpose, putting his Saskatchewan fisheries experience to good purpose (Novakowski 1958c*, 1959c*).

In 1962, when anthrax struck the Bison population just outside WBNP, it was the first recognized instance in Canada of anthrax in wildlife and all concerned were faced with a very steep learning curve. Nick worked closely with a team of scientists from the Canadian Wildlife Service, the Health of Animals Branch of the federal Department of Agriculture, and medical personnel to bring it under control (Novakowski et al. 1963; Choquette et al. 1972).

Dr. Fuller had engaged the interest of a long-time trapper in the southern portion of WBNP, Solomon Lacaille, to help with Muskrat studies (Fuller 1951). Nick followed through and set up a multi-year study on Mr. Lacaille's trapline to study many aspects of beaver biology and ecology, leading to his Ph.D. from the University of Saskatchewan in 1965 (Novakowski 1965a*, 1967a, 1969a).

The nesting grounds of the Whooping Crane, long an international mystery, were discovered in 1954 in the northern portion of Wood Buffalo National Park. In the subsequent two years the site was monitored by Dr. W. A. Fuller. Nick took over those studies in 1956 and monitored the small breeding population for several years (Novakowski 1966, 1967d). He was also responsible for capturing an injured juvenile whooper in 1964 and for ensuring its safe conduct to the breeding facility of the United States Fish and Wildlife Service near Washington, D.C. (Novakowski 1965b, 1965e*). That bird, a male named "Canus" for its dual nationality, sired "over 180" (E. Kuyt, personal communication) Whooping Cranes over its long career. It died in January 2003. The mounted body was repatriated to Canada and is now installed at the Northern Life Museum in Fort Smith, N.W.T. (E. Kuyt, personal communication).

Nick's work on Wood Bison and Whooping Cranes introduced him to the burgeoning field of rare and endangered species. It was a field that would occupy much of his attention for the remainder of his life. The Canadian Wildlife Service moved Nick to a Staff role in Ottawa in 1966. J. Anthony Keith, who was Nick's immediate superior in the Canadian Wildlife Service for much of his time in Ottawa, reported that "Nick Novakowski was the founding voice in CWS headquarters for wide-scale collaborative action on endangered species, beginning in 1967 when he was Staff Specialist, Mammalogy. While his own earlier work on Whooping Cranes became the trademark federal endangered species project, there was a continuing debate amongst headquarter staff about how far CWS should get involved in endangered species work. Nick had to argue against those who saw it as a diversion of limited resources from urgent wildlife conservation issues. He worked with Ted Mosquin to produce the first set of scientific articles in Canada on endangered vertebrates (*The Canadian Field-Naturalist* 84(1) 1970), writing the article on mammals." [*See* Novakowski 1970b].

In 1973, Nick represented the Canadian Wildlife Service at the international negotiations in Washington of what became the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While John Heppes joined CWS to establish the Canadian management authority for CITES, Nick chaired the scientific authority until he retired in 1983 (Burnett 1999, page 162).

Nick Novakowski and John Heppes worked well together. Their first task was to convince provincial governments that CITES would not interfere with provincial authority over wildlife resources. John dealt with the administrators and enforcement personnel while Nick met with the wildlife managers and scientists. "Nick showed an amazing understanding and ability in persuading all concerned to fully cooperate ..." (J. Heppes, personal communication). Canada ratified the Convention in early 1975. Every two years there was

a "Conference of the Parties" at which member nations negotiated changes. "It was at these Conferences that Nick really proved his worth. In his role as Scientific Advisor he was always able to present the Canadian viewpoint in a clear and concise manner. While usually a calm and collected person, Nick could at times be very forceful in getting the Canadian opinion across … he was respected by many international authorities who often sought his advice on biological status of endangered species and his assistance in presenting their positions." (J. Heppes, personal communication).

Eugene Lapointe, the first Secretary General of CITES, remembers Nick's contributions for their scientific rigour and said, "My recollection of Nick is that he played a key role at the CITES meeting held in Gabarone, Botswana in 1983. The international community had an opportunity to realize what real and credible science was all about, and that thanks to Nick. I always perceived him as one of the most candid scientists. He was highly respected by his peers from the CITES community" (E. Lapointe, personal communication).

I recall one meeting in Ottawa where Canadian Non-Government Organizations (NGOs) were presenting their concerns about an upcoming Conference of the Parties. Two delegates were particularly vociferous in their assault on a proposed Canadian position. Nick as usual was thoroughly prepared and met both scientific and emotional arguments with calm, well-reasoned, non-confrontational responses which won the day.

Nick was also front and centre in the discussions leading up to the establishment of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Ted Mosquin recalled that as he was preparing draft recommendations for an upcoming symposium on Canada's Threatened Species and Habitats in 1975 Nick suggested that he look into the UK model that had "a unique committee that addressed the matter of the status of endangered species in the UK. [Nick] came over to the CNF office to fill me in on how the UK system worked. The result was a draft recommendation … which led to almost immediate establishment of COSEWIC by agreement of CWS and provincial agencies via the Federal Provincial Wildlife Conference" (T. Mosquin, personal communication).

"Throughout Nick's work as a senior scientist in headquarters, he maintained a network of colleagues in provincial and territorial governments. Nick's credibility with these colleagues was vital in their governments' agreement in 1977 to the initiative that became the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), with Nick elected as its first permanent secretary. During the first formative years of COSEWIC Nick did outstanding work helping to forge a new way of doing business, helping to bring federal, provincial, territorial and non-government agency people to agree on publicly-released status reports. Making public the facts about endangered species was what Nick had been calling for since 1967, believing that this would lead to remedial actions supported by the public. COSEWIC continued to grow in the spirit of Nick's early aspirations, and recently was established as a formal entity under the *Species at Risk Act*." (J. A. Keith, personal communication).

In addition to Nick's work as COSEWIC secretary, he maintained his avid interest in species biology. He wrote the original Wood Bison status report and contributed to others. He also chaired the Marine Mammal and Terrestrial Mammal subcommittee in 1980 and, when it split, he chaired the Terrestrial Mammal subcommittee from 1981 to 1984.

Dr. Novakowski was involved in a much broader scope of activities than this review can encompass but three items may help to round out the story. For a number of years in the 1960s and 1970s he was involved with the search for more humane traps for capturing furbearers. His field experience with trappers proved very useful. He thoroughly understood the trappers' needs (Novakowski 1958d*) and also the political pressure being created to do away with the leg-hold trap. In 1967 he gave a brief but cogent review of the problem to the Federal-Provincial Wildlife Conference (Novakowski 1967e) and continued to be involved with the resulting program to develop humane traps until his retirement. Another example of his varied work involved blocking the introduction by an Ontario fur rancher of several dozen Raccoon Dogs (*Nyctereutes procyanoides*) from Finland. When the news arrived on Nick's desk, he nearly blew a fuse! He was one of the very few people in Canada who had the knowledge to foresee a disastrous outcome if those animals were allowed to stay. He knew from the literature and from his many European colleagues that if the animals ever got loose the species could have devastating ecological effects. And he knew that no matter what precautions were taken, sooner or later some of them would get loose. He sought the assistance of Dr. Eric Broughton, a veterinarian with the CWS, to have Agriculture Canada deny the import permit. No dice – there was no basis for denial on environmental grounds. Nevertheless, based on knowledge of the ecology of the species, he convinced Canadian authorities that the animals posed an unacceptable threat to Canadian wildlife and obtained authorization to have all of the imports killed, the pelts processed by the Hudson's Bay Company and compensation made to the owner. But he didn't leave it there. Nick pursued the problem domestically and with the United States authorities resulting in a formal Canada–USA agreement to bar the future importation or Raccoon Dogs into either Canada or the USA (E. Broughton, personal communication). A third dimension of Nick's professional work involved teaching a variety of courses, including biology, terrestrial ecology, and wildlife management at University of Ottawa, the University of Guelph, and Sir Sandford Fleming College in Lindsay, Ontario.

After retiring from the Canadian Wildlife Service in 1983, Dr. Novakowski became active as a scientific

consultant and engaged in a wide range of projects. In some cases he worked independently. In most he served as a member of a consulting team. In one of his early projects, he worked with Ted Mosquin to consolidate and review many earlier reports on Caribou and fur-bearers in Pukaskwa National Park (Novakowski and Mosquin 1986a*, b*, c*, d*). Dr. Mosquin recently commented: "Nick provided the publications/reports, guidelines, policies, appendices, survey data, illustrations, etc. as well as some text. I basically organized and wrote the reports based on the material and discussions. He was the expert. We worked well together and I learned a lot! ... We sometimes sat for more than a few hours trying to figure out what needed to be said and how to best say it."

Several of Dr. Novakowski's post-retirement projects dealt with major Environmental Impact Assessments of such projects as the Military Low-Level Flying program in Labrador, uranium mining in northern Saskatchewan, the Rafferty-Alameda dams proposal in southern Saskatchewan, military base proposals in the arctic, and bison management in Wood Buffalo National Park. He became very knowledgeable about environmental impact assessments in Canada and contributed behind the scenes on a variety of policy issues. He also contributed to a review paper on the evolution of environmental impact assessments of watershed modification projects (Dirschl et al. 1992).

In 1982, a year before Nick retired from the Canadian Wildlife Service, Dr. Husain Sadar arrived at the Federal Environmental Assessment Review Office (FEARO). In a letter following Nick's death, Dr. Sadar wrote that one of his "major responsibilities was to organize teams of highly recognized, accomplished and credible independent experts and specialists to assist and advise [the independent review panels] for analyzing and addressing often complex scientific, technical and socio-economic issues ... Nick served as an independent expert for several panels [dealing with] some of the most difficult, controversial and complex mega project proposals ... the panels benefited immensely from Nick's unique experiences and expertise in wildlife management and habitat protection. Whether the issue was protection of caribou herds, moose, large carnivores, furbearers, waterfowl, seabirds, birds of prey, marine birds or deer, Nick's critical analysis, evaluation and resolution of all such issues was simply outstanding ... But the most important quality of Nick's wonderful character was his ability to interact and work with other professionals in a highly professional, civilized and friendly fashion. He truly was a real gentleman."

Dr. Herman Dirschl, with whom Dr. Novakowski collaborated on many contracts, recalled their joint efforts on some of those major projects and commented, *inter alia* that, "Nick could be very passionate in his views, particularly when political decisions seemed to often favour short term economic gains at the expense of the long term environmental health. However, he managed to always stay calm and collected in the face of such adversity. I admired him for this ability and will greatly miss him." Dr. Dirschl also recalled their work "on an assessment of priority habitat sites throughout Canada to be considered for protection by the Canadian Wildlife Service in concordance with the Federal Government's 'Green Plan' goals. Nick took on the responsibility for reviewing the site records for a total of 262 sites in all provinces and territories; designing a classification system and defining latitude/longitude centroids for each site."

Even Canada Post sought out Dr. Novakowski's advice in planning for a commemorative postage stamp featuring Beaver – the 150th anniversary of the original 3¢ Beaver stamp (Novakowski 1997*).

Nick the scientist was also Nick the practical environmentalist. Early in their stay in Ottawa he and his wife, Amy, bought 150 acres of forested land in nearby Lanark County. It was covered primarily with second growth hardwoods but also had a small plantation of Red Pine which Nick carefully nurtured. He became very interested in the "Model Forest" concept and was a very keen member of the "Eastern Ontario Certified Forest Owners."

I leave the closing words to his good friend, car pool partner and long-time professional colleague, Gerry Lee: "On a house visit one day, Nick invited me into his garage to see his latest pride and joy. There sat a beautiful cedar strip canoe, like a collector's piece of rare furniture, hand built by canoe builder Nick for one of his offspring. Apart from the odd comment previously about 'building a boat someday,' I had no inkling of his interest or talent in this area. So much for thinking you know someone! To sum up, Nick to me was the consummate good guy; respected professional, devoted family man, equally devoted environmentalist, polite, humble and honest. A good friend I'll never forget."

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Book Reviews

ZOOLOGY

The Birder's Companion

By Stephen Moss. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 208 pages. U.S. $16.95

This book is an entry in the "everything you ever wanted to know about birds" category. Each of its ten chapters deals with some aspect of birds – where do birds live? How do birds eat? Where do birds go? And, yes, each chapter does consist of a series of questions and answers – over 450 in all – together with side-bars giving what can best be described as "gee-whiz" facts relevant to the chapter's topic, all in roughly 20 pages or less each.

Maybe a disclaimer is appropriate at this point – this kind of book turns me off. With that out of the way, Moss has done a creditable job in amassing a formidable series of facts and presenting them in a simple, colloquial style. In the introduction the author quotes a friend who suggests the book would appeal to "intelligent, inquiring eleven-year-old boys", and while the author clearly hopes to appeal to a much wider audience, he makes no apology for his approach.

In spite of its disarming level of simplicity, the book is very well thought-out, up-to-date, and quite accurate. I imagine I could find an error or two in all this mass of data if I tried hard enough, but the fact remains that I didn't. He even – glory be – gives the correct origin for the word "jizz" , with no inanities about "general impression of size and shape" usually parroted as the origin nowadays. My main quarrel with the text is the inevitably high level of simplification, which constantly left me feeling "yes, but..." Some of the author's generalizations seemed very broad, and I wondered how he arrived at them; but again the ones I could check seemed within reasonable bounds.

The author is British, and this can sometimes be a problem when writing for a North American audience. However, in this case the book is very carefully tailored to North America. One minor area where it could be misleading was in references to "buzzards", the European name for *Buteo* hawks, but also a term colloquially used in parts of North America for vultures. Not only are we not told what buzzards are, but there are no buzzards in the index. One reference, to them being eaten by the European Eagle Owl [also not in the index]; was a particularly poor choice, given that Great Horned Owls will attack Red-tailed Hawks similarly.

The weaknesses in the index are by no means confined to these two examples. It seems to place most of its emphasis on the material in the side-bars, and the text as a whole is far less well covered. This is particularly unfortunate because for me, at least, this is not a book to read from cover to cover, but is best dipped into from time to time, as some topic of interest arises. For such uses, a thorough index is very important.

There is a one-page bibliography, although again some transatlantic emphasis creeps in, as many of the references are British – it's hard to see the relevance of the UK breeding bird atlas – but more importantly they may be hard to find on this continent. The line illustrations are not one of the strengths of the book.

My carping aside, this book would appeal to novice birders or anyone with a mild interest in birds. Its appeal to more experienced birders is perhaps more limited, but it's an easy read, best taken in small doses, and you'll probably find some things you didn't know. And I seriously think it could be a very good gift for intelligent, inquiring eleven-year-olds.

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Birds of the Dominican Republic and Haiti

By Steven Latta, Christopher Rimmer, Allan Keith, James Wiley, Herbert Raffaele, Kent McFarland, Eladio Fernandez. Princeton Field Guides, Princeton University Press. 2006. 258 pages. U.S. $35.

Hispaniola, the second largest island in the Caribbean, has a wealth of habitats and of birds, making it an emerging destination for birdwatchers. It also has immense development challenges, most acutely felt in Haiti, the poorest country in the western hemisphere. These development challenges translate into conservation challenges, putting Hispaniola's ecological richness at peril. This book, the latest in several Caribbean guides issued by Princeton, is thus doubly important, both as an aid to identifying the island's birds, but also as a valuable conservation tool which maps the current avian diversity of the island and communicates the value and beauty of the island's birds to local populations.

The book will be instantly familiar to anyone who has seen any of Princeton's earlier Caribbean guides, such as *A guide to the birds of the West Indies* by Raffaele et al. Indeed, some of the plates have been taken from that earlier guide. The book follows a standard formal, with front pieces speaking to the topography and habitats of the island (from the highest mountains in the Caribbean, at 3098 m, to the lowest lake, at 44 m below sea level), endemic species (31) and subspecies (50), avian conservation, and the island's ornithological history. This is followed by detailed species accounts with information on similar species, vocalizations, habitat preferences, status, nesting, and global range, as well as a "comments" section containing interesting anecdotes such as the place of the bird in local culture. Each species account is accompanied by an up-to-date, detailed map of the bird's distribution on the island. This information is complemented by 56 colour plates, most of which group up to 10 similar species however, pride of place is given to the island's endemic species and one endemic family (Palmchat), which merit larger portraits. The book closes with descriptions of 14 birding sites and a checklist.

The species accounts are accurate and provide sufficient information to identify most species. Particular attention is paid to the resident species most likely to be of interest to visitors, thus ensuring that one is indeed able to safely differentiate Long-billed and Narrow-billed Todys, the vireos, and other potentially confusing groups. Canadian readers will find the discussion of Bicknell's Thrush of interest as Hispaniola is the chief wintering ground of this enigmatic breeding species. In general, the treatment of migrants is better than in many other regional guides; while you might want to lug around a good North American guide for some of the shorebirds and basic plumaged warblers, the level of detail in the plates is impressive and will usually suffice (e.g, if you look closely you can see the differently marked tertials in the illustrations of Long-billed and Short-billed dowitchers). In general the plates have the rather washed out and sombre tones of the earlier Princeton guides, and in some of the portraits the feathers have a rather messy look, not unlike old museum specimens, but this is a stylistic quibble; on the whole the plates are very good. While the decision to illustrate all 306 species which have been recorded on the island has considerable merit, having three illustrations of a bird which has only occurred once (Swainson's Hawk) would seem an inappropriate use of always scarce space.

The authors largely follow standard taxonomy, but have jumped the gun on American Ornithologists' Union orthodoxy by accepting recently proposed revisions, such as treating the Hispaniolan Nightjar as distinct from the Cuban Nightjar, both traditionally combined as one species known as Greater Antillean Nightjar (confusingly, the latter name is used in the similar species account under Least Pauraque, one of relatively few editorial errors in the book). Similarly, the authors have abolished the names of two endemics, Green-tailed Ground-Warbler and White-winged Warbler which have now morphed into Green-tailed Ground-Tanager and Hispaniolan Highland-Tanager, respectively. Some other incipient splits and lumps are suggested in the text, reflecting the fact that yet more work needs to be done on the island. Likewise, the species accounts indicate that several species have been added to the island's avifauna in the last decade, suggesting a recent increase in coverage and the possibility that the island's bird list will grow: the local occurrence of several pelagic species in particular seems to be poorly known.

Who should buy this book? Someone with a general interest in Caribbean birds may be better served by *A guide to the Birds of the West Indies* by Raffaele et al., which covers Hispaniola along with the rest of the islands. But anyone planning to travel to this beautiful island, or with a keen interest in Caribbean ornithology, would be well advised to acquire a copy; the range maps and site guides alone are worth the price if you are planning a self-guided visit (but better still, go with one of the organizations cited in the book). Finally, and most importantly, there should be a copy in every school and public library on the island: one hopes that Spanish and French versions are in the works.

MARK GAWN

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Atlas of Bird Migration – Tracing the Great Journeys of the World's Birds

Edited by J. Elphick. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 176 pages. $35.

Firefly Books has come out with another decent book. They've claimed the target audience to be, "bird enthusiasts, naturalists and the inquiring reader" and those who "wish to comprehend the perilous voyages that constitute one of the great wonders of the natural world." The book is written to be consumable by people in grade school and perhaps almost fully understood by those as young as 12 or 14 years of age; it will be an enjoyable, and not too taxing to read for adults who have a passing interest in the topic. Serious birders will want to go elsewhere for more in-depth descriptions of the topics.

The book starts out with 15 two-to-four page chapters on the biology and environmental conditions of migration, including timing, flight styles, genetics and weather. For the most part, these are well-illustrated

synopses of the topics. The subsequent chapters are organized into sections covering major geographic areas (e.g, Eurasia, southern hemisphere, oceans), with two to eighteen chapters per section. Each chapter covers an order or family of birds, using one to four species as examples. There is a map as well as a calendar showing migration and breeding times for most of the illustrated birds.

Although the book is worldwide in scope, it is dominated by a British point of view; after the typical migration pattern of a species is noted, the accidental occurrences in Britain (but nowhere else) are described (if such has occurred). The global perspective is worthwhile, though only a small fraction of the planet's migratory birds can be described.

There are a few mistakes scattered throughout the book; these include classifying the Great Horned Owl as an irruptive species, labelling Lake Winnipeg and its neighbours as the Great Lakes and describing the furcula as a pit (it is the wishbone). Many folks will gloss over these, but the more demanding reader will catch them; mistakes are never desirable, but most of these are relatively minor.

In addition to covering distance migrants, the book pays some attention to altitudinal migrants. When appropriate, the authors have included conservation messages on topics such as introduced species, habitat loss and the implications of commercial fisheries on birds.

Overall, this wouldn't be a book I'd give one of my serious birder friends as a gift, but it would do nicely for the beginner who is just migrating into the hobby.

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Handbook of the Birds of the World Volume II – Old World Flycatchers to Old World Warblers

By Josep del Hoyo, Andrew Elliott and David A. Christie (Editors). 2006. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 800 pages. 199 Euros Cloth.

Handbook of the Birds of the World. Volume II covers eight families containing 733 species each with its own account and distribution map. The first of these is the Old World Flycatchers which, with the prejudices of youth, conjure up visions of Little Brown Jobs (LBJs). LBJs are the birders bane; small obscure birds that are difficult to see and identify. My first encounter with an Old World Flycatcher was the Spotted Flycatcher. This is an LBJ where "spotted' is an overstatement. They are only faint marks on the breast. This is a sweeping and somewhat unfair assessment as more than 40 percent of Old World Flycatchers are colourful. Indeed, the 22 members of *Cyorrus* are as colourful as North American Bluebirds.

In the next family, the Batises are small and largely black-and-white, whereas Wattle-eyes are somewhat more colourful with some orange and yellow. Many of the Monarch-flycatchers are a smart blue, but others are black and brown or black-and-white. However, the members of the small family of Paradise Flycatchers are among the most spectacular of the world's birds. One of my life's highlights was seeing the display of the black-and-white morph of the Madagascar Paradise Flycatcher. Similar and equally impressive species live in Africa and India. Kinglets and Firecrests is a family that is split between the old and new worlds. They are woodland sprites that can be surprisingly "cute" despite an initial dull impression. Gnatcatchers is a family of small, grey, long-tailed birds and is the only one in this volume that is confined to the new world. To my mind their counterparts are the Prinias of Africa and Asia.

Cisticolas and allies are a bit of a nightmare. Most of them are true LBJs being streaky or dull brown. Knowing their songs and distribution helps. Even the easier to recognise birds like the Common Jery of Madagascar and the long-billed Tailor Bird of Asia can be a problem. They are so active that critical characteristics can be hard to see. Whenever you think you have seen all the relevant characteristics, after the bird has flown, you often discover there was something critical you missed!

The 270 species of Old World Warblers in the Sylviidae (with 14 species confined to the antique island of Madagascar) are mostly LBJs. They are some of the most difficult birds to identify in the field. This nightmare is composed of several genera with hyphenated names like bush-warbler, reed-warbler, leaf-warbler and swamp-warbler. While there are discernable differences between, say, leaf- and swamp-warblers within each group there are many look-alike species which vary only by minuscule differences in eye-stripe or bill length. I spent every lunch hour for two weeks beside a Willow Warbler's nest so that I could identify this species with confidence. This meant I could better see the subtle difference between Willow Warblers and Chiffchafs [greener versus browner, etc.]. Unfortunately these birds are variable. The reader need only compare the photo of a pale, greyish Willow Warbler on page 551 with the brownish-yellow one on page 514 to understand this difficulty. It gets even worse with birds like the newly split Booted Warbler [*Hippolais caligata*] and Syke's Warbler [*H. rama*] Syke's Warbler winters all over India whereas *H. caligata* is found only on the eastern coast between the Ganges and Pondicherry. So the two species overlap in the east and are almost identical. As they do not sing in winter it will take a DNA test to separate them!

So how did *Handbook of the Birds of the World. Volume II* fare in dealing with birds that are not as magnificent as albatross or wildly coloured like parrots? It actually does remarkably well. Once again we have a well-organized and researched volume that adds to the

growing status of this project. As each new volume is produced it adds to the benchmark status of the existing volumes as a primary source of information on the world's birds. The format has remained stable for the last several volumes, which makes it easy to use and compare. The photos are top rate despite the small and obscure nature of these species. I know how difficult it is to get **any** photographs of such little and active sprites, let alone artistic ones of birds singing or displaying. *Handbook of the Birds of the World* has now reached biblical reference status.

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Conservation of the Black-tailed Prairie Dog: Saving North America's Western Grasslands

Edited by John Hoogland. 2006. Island Press, Washington, DC. 350 pages paperback U.S. $35.

It is amazing how the conservation of an animal as interesting and entertaining as the Black-tailed Prairie Dog can be so controversial. But controversial it has been in the last few decades as environmental interests have woken up to the fact that the campaign of Prairie Dog poisoning and habitat loss has resulted in a range contraction to less than 2% of the historical geographic distribution. To this day many ranchers actively dislike Prairie Dogs for their competition with livestock for rangeland resources. In contrast, some conservation practitioners think that enough other species rely on the habitat created on Prairie Dog colonies that Prairie Dogs should be considered a keystone species. In my own practice as a biologist at Grasslands National Park, Saskatchewan, I have frequently been taken aback by how polarized the opinions on Prairie Dogs can be between individuals and groups that often share many similar core values.

The book, *Conservation of the Black-tailed Prairie Dog: Saving North America's Western Grasslands* is the brain child of Dr. John Hoogland who has researched the behaviour of Prairie Dogs at Wind Cave National Park in South Dakota since the mid-1970s. Dr. Hoogland felt that there was a need to summarize the extensive scientific literature on the Black-tailed Prairie Dog in a non-technical format designed to highlight the information's relevance to conservation. To accomplish this Dr. Hoogland engaged 30 other specialists and challenged them to draw out the lessons for conservation from their areas of specialty. These lessons are explored through 18 chapters on topics such as natural history, social behaviour, competition with livestock, keystone species, human attitudes, and how to establish new colonies of Prairie Dogs. The chapter authors are all respected specialists and do an excellent job of relating their topic area to the central theme of the book: the conservation of Black-tail Prairie Dogs.

The only significant criticism I have is that Dr. Hoogland repeatedly states in Chapter 2 that Black-tailed Prairie Dogs do not hibernate. This is odd because published studies have shown that Black-tailed Prairie Dogs use facultative torpor (Lehmer et al. 2001). In fact, in southwestern Saskatchewan, at the northern edge of their distribution, Black-tailed Prairie Dogs spend as much as 95 days a year in winter torpor bouts lasting 7.6 to 13.6 days with minimum core body temperatures ranging from 7.1 to 11.6°C (Gummer 2005). Clearly, this behaviour deserved to be recognized and discussed as to how it might relate to efforts to conserve this species. Despite this small failing, I fully recommend this book to anyone interested in the conservation of this fascinating social rodent or who wants to become better informed on conservation issues on the Great Plains.

Literature Cited

Gummer, D. L. 2005. Geographic variation in torpor patterns: The northernmost populations of prairie dogs and kangaroo rats. Ph.D. dissertation, University of Alberta. 210 pages.

Lehmer, E. M., B. Van Horne, B. Kulbartz, and **G. L. Florant.** 2001. Facultative torpor in free-ranging black-tailed prairie dogs (*Cynomys ludovicianus*). Journal of Mammology, 82(2): 551–557.

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Migrating Raptors of the World: Their Ecology and Conservation

By Keith L. Bildstein. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850 USA. 332 pages. U.S.$35.00 Cloth.

Raptors and bird migration both hold great fascination throughout the world, so the combination of the two topics makes for an irresistible book. Bildstein is a foremost world authority. Based at Hawk Mountain, the world's first site dedicated to the conservation of hawks and the watching of their migration, he is the Sarkis Acopian Director of Conservation Science. Bildstein tells us that "a bad day at Hawk Mountain Sanctuary is better than a good day anywhere else."

His wide knowledge derives in part from his travels to each of the world's main hawk-watching sites. Figure 1 displays the five major hawk pathways throughout the world and Figure 7 shows the 12 locations where 100 000 or more raptors pass by. In addition to studies at Hawk Mountain, banding of thousands of raptors has occurred at Cedar Grove, Wisconsin; Cape May, New Jersey; Hawk Ridge on Lake Superior, Minnesota; the Goshute Mountains, Nevada; the Manzano Mountains, New Mexico, and Golden Gate Observatory, California. Notable Old World banding sites are Chokpak Pass, Kazakhistan, and Elat, Israel. Switching

to birds counted overhead, 851 600 Honey Buzzards flew over Elat in the spring of 1985; there the spring flights are much larger than in fall. Elsewhere large numbers are counted in the fall: an average of 730 000 at Corpus Christi, Texas; 5 200 000 near Cardel in the state of Veracruz, Mexico; 1 950 000 at Keköldi Indigenous Reserve, Costa Rica, and 380 000 over the Strait of Gibraltar at the western end of the Mediterranean. In Veracruz, sometimes dubbed the "river of raptors," 2 677 355 Turkey Vultures were counted in 2003, 2 389 323 Broad-winged Hawks in 2002 and 1 197 850 Swainson's Hawks in 2003, including 782 653 in one day, 17 October that year.

Recent advances in technology have provided a big boost to raptor migration studies. Application of satellite radios to 117 Ospreys and 51 Golden Eagles added immeasurably to our understanding of the speed and variability of migration. Nine satellite-tracked Honey Buzzards averaged 270 km/day across the Sahara Desert, with brief stopovers suggesting that most fasted during at least this leg of their trip south. Since raptors often reduce energy requirements by soaring in thermals, Bildstein has included a map and three diagrams of the major deflection/updraft corridors. Raptors are able to orient and navigate simultaneously (setting a direction and then achieving it), using internal magnetic cues, visible landmarks, the sun by day, the stars for the few species that migrate by night. Despite a great deal of research, their navigational prowess still exceeds human comprehension. In at least nine species, including harriers, accipiters and two falcons, the juveniles precede the adults in southward migration, yet come spring the adults often head north first. In the Osprey and a few other species, juveniles spend an extra year in the tropical wintering habitat before returning north at two years of age.

A positive feature is that a number of hawk watching stations, including Hawk Mountain, were founded as conservation measures. Incensed by the carnage along the Kittatinny Ridge at Hawk Mountain, Rosalie Edge purchased the property and hired Maurice Broun to patrol it and count the raptors. Rachel Carson, in *Silent Spring* in 1962, used the 25-year Hawk Mountain counts, especially of declining Bald Eagles, to support her arguments concerning the impact of organochlorine pesticides, especially DDT, on the reproductive success of birds of prey.

Bildstein's final chapter is perhaps the strongest. It explains the widespread effects of bounties, not completely eliminated in Pennsylvania until 1969. From 1917 to 1952, Alaska territory paid bounties on 128 000 Bald Eagles. Today, the main threats to raptors are habitat loss and environmental contaminants, an example being a painkiller, diclofenac, fed to cattle in India, that has led to population declines of over 90 per cent for three species of vulture that eat dead cows.

My only criticisms are small ones. Because owls are also raptors, the absence of any mention of their nomadic movements, cyclical irruptions and migrations is somewhat contrary to the title of this book that is restricted to diurnal raptors. Readers of the main text might believe that DDT has long been banned everywhere, but in fact it is still being used in tropical countries to combat malaria and yellow fever. Only in the Glossary does Bildstein inform his readers that DDT is "still used by public health organizations to control malarial mosquitoes."

The writing is clear. Each chapter (I have only touched on a few highlights) ends with a synthesis and summary of the main points. This book is a treasure. It belongs in every high school and college library and in the library of every raptor enthusiast.

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Land Snails of British Columbia

By Robert G. Forsyth. 2004. Royal British Columbia Museum, Victoria, British Columbia, Canada. 188 pages. $35. Paper.

The study of snails has certain advantages for a naturalist. For one thing, unlike birds or butterflies, they move slowly enough to be identified! However, anyone who has ever tried to identify snails will know that there is a dearth of readily accessible information out there to help with the task. This is a lack that Robert Forsyth has set out to remedy with his guidebook, providing help with the identification of 92 species of land snails and slugs found in British Columbia. This book is similar in layout and format to other recent guidebooks from the Royal British Columbia Museum, a handy 5.5" × 8.5" soft cover book, easy to slip into a backpack or daysack.

Each taxon is provided with a "species account" that consists of a description of the animal, its distribution, and its natural history (basically its habitat preferences). Each account also includes information on the etymology of the animal's name, some remarks, usually dealing with taxonomic issues or species with which it may be confused, and references. The species are arranged in taxonomic order. These accounts form the bulk of the book (128 pages). Most taxa are illustrated by line drawings or black-and-white photographs. For the planispiral snails, the images generally include the upper (apical) surface, lower (umbilical) surface, and apertural view. For the conispiral snails, the images generally consist of an apertural view and a distal view. There are also 33 colour images, of which 23 are of slugs. These colour images are generally much crisper and more useful than the black and white photos. Forsyth includes some brief discussion of eleven other taxa that he considers of doubtful occurrence in British Colum-

bia or that he judges to have equivocal taxonomic status. These are often species that were perhaps only recorded from one locality or for which the record was made many decades ago and has not been confirmed or supported by subsequent observations.

These species accounts highlight some interesting points about the land molluscs of British Columbia, as they are known at present. Of the species discussed, about one third (24) are slugs. Of these, more than half of them (13) are introduced. Many of these slug species are described as being common in gardens, which perhaps suggests that eagle-eyed gardeners may be responsible for drawing attention to them. Forsyth notes that many of these exotic species are significant agricultural pests, in contrast to members of the native fauna, which are not. He points out (page 19) that most may have been accidental introductions, brought in on plants or associated soil. Most of the snail species, in contrast, are native (53) with less than a quarter (15) identified as introduced. This striking pattern raises the question as to whether it is a consequence of the method of introduction (that is, on horticultural or agricultural plants) or simply a lower level of investigation of the mollusc fauna outside urban and intensively farmed areas. Despite its focus on British Columbia, many native species described by Forsyth have wider distributions. Some are found in other areas in the Pacific Northwest, from Oregon to Alaska. Others are more widespread and some occur east of the continental divide in other areas of western North America. Despite its focus on British Columbia, therefore, this book has wider applicability in western Canada.

The remainder of the book offers useful supplemental information. An extensive introduction (19 pages) describes the biology of the animals, including, for the snails, some discussion of shell characteristics, which are important for species identification. There is also a checklist of the species described in the volume, and two dichotomous keys, one for snails and one for slugs, to help narrow down the selection to genus. Ten other keys are interspersed among the species accounts and focus on genera, such as *Vallonia*, *Vertigo*, and *Arion*, in which there are more than a couple of species. All the snails described are dextral coiling species, as are most land snails. Following the species accounts, there is a lengthy (14 pages) reference list, a glossary of terms, and a species index.

I obtained this book primarily to help with the identification of mollusc shell remains recovered from fine-fraction analysis of sediment samples from archaeological sites and other postglacial depositional contexts. In these situations, the soft parts of the animals are not preserved and only the shells remain. Hence, identifications rely primarily on the morphology and structure of the shells. So I was particularly interested in the shell descriptions. In this regard, the book has been very helpful although I have noticed some limitations. My main complaint is that the line drawings are not reproduced well. This is a significant problem. On many drawings, the lines are faint and details of shell surface features and ornamentation are extremely difficult to discern. Moreover, Forsyth only provides one shell measure for each taxon. For the planispiral molluscs, he provides the width of shells, but not the spire height. For the conispiral molluscs, he provides the height of the shells, but not the width. The complementary measures can be approximated from the drawings, but it would have been useful to have them included in the text. The width/spire height ratio is an easily acquired descriptive character that helps discriminate different taxa.

Two additional sets of information would have made this book even more helpful. First, I thought each species could have been illustrated by a "dot map" showing the localities in British Columbia where it has been collected or observed. I imagine that the dots would have been very sparse for many species! Nevertheless, such maps could highlight areas that may well repay survey and collecting effort. Second, it would have been useful to have a list of the accession numbers for the specimens that were studied to compile this volume. This is important so that in future scholars could re-examine the specimens to confirm and refine the taxonomy or acquire additional measurements and images. Because the Royal British Columbia Museum is the publisher, I assume that it may be the institution housing these collections. However, this information (that is, the institutional repository and accession numbers) could have easily been included, for example, in the species checklist, making such detective work unnecessary.

Compiling this volume obviously involved a formidable amount of painstaking work and study. I heartily commend Forsyth's commitment to a neglected but rewarding faunal group. This book is a fine introduction to these animals and deserves to be on all western Canadian naturalists' bookshelves. Anyone who pays attention to the information in this volume will never look at a snail on a rockery or a slug on a cabbage leaf in quite the same way again!

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Songbird Journeys: Four Seasons in the Lives of Migratory Birds

By Miyoko Chu. 2006. Walker & Company, 104 Fifth Avenue, New York, New York 10011 USA. 312 pages. U.S. $23. Cloth.

This is a welcome, attractive, and highly recommended book. Each chapter is preceded by a well-chosen quotation, often an appropriate full-page poem.

Miyoko Chu has combined the best of investigative journalism with a passionate account of bird migration that holds the reader's attention. Four chapters deal with spring migration and two with fall migration. She also must deal with where these migrating birds summer and winter, so five chapters deal with these intervening seasons. Not only does she tell of the latest research into bird migration, but she interviews at length some of the leading authorities. Thus, we read fascinating stories about exceptional people who are studying interesting birds. I will mention a few highlights.

Her opening chapter deals with a long-unsolved question: do large numbers of birds make the seemingly impossible long-distance flight over the Gulf of Mexico, as George Lowery fervently believed, or was this a preposterous fiction of people's imaginations, as George Williams posited? Lowery began by studies through a telescope, and admitted that trans-Gulf migration was "fraught with enigmas and strained one's credulity." Williams accused Lowery of jumping from minute observations to sweeping conclusions, of extrapolating from the 12 birds he had seen through the telescope to claim a migration of 21 million birds. Sid Gauthreaux, when 17 years old in Louisiana, inveigled his way into one of the first weather radar stations and persuaded the meteorologists to let him look at the fuzzy dots that he thought must be movements of birds. He then persuaded Lowery to accept him as a graduate student, embarking on a master's thesis and then a doctoral dissertation that proved to doubtful ornithologists everywhere that radar was a superb modality for studying many aspects of migration. In so doing, he proved beyond doubt that Lowery was correct.

Frank Moore's group at Johnsons Bayou, Louisiana, studied weights and condition of migrants as they first reached landfall, after crossing the Gulf. Almost half the birds arrived with their fat reserves totally depleted.

Richard Graber, at Urbana, Illinois, was an incredibly early pioneer, four full decades ahead of the pack, in placing tiny radio transmitters on small birds. His friend, Bill Cochran, made him a number of tiny, 3 g transmitters, which he glued to the backs of thrushes that weighed about 30 g each. He tuned his receiver to the appropriate frequency and then followed the signals by truck, and once by aeroplane for 400 miles in eight hours. Cochran then took over the study and with special equipment he logged 150 000 miles by truck to follow individual birds for a total of 30 000 miles. He followed one Peregrine Falcon from Wisconsin to Tampico, Mexico, a Sharp-shinned Hawk from Cedar Grove, Wisconsin, to Huntsville, Alabama, and a Common Nighthawk from Illinois to South Carolina.

Another hero is a bird, a Yellow Warbler, nicknamed "Wally," that carried band 1750-17109, and returned for nine years in a row, to sing near the Long Point Bird Observatory in Ontario. At Hubbard Brook in New Hampshire, where Richard Holmes and his colleagues have studied birds since 1969, bird numbers have declined by about sixty percent. There, Black-throated Blue Warblers produce more young in years when caterpillars are common and in La Niña years.

When Olin Sewall Pettingill was a boy in Maine, his mother showed him a Bobolink nest. But they faced hazards. About 720 000 Bobolinks were shipped as game from one place in South Carolina in 1912 alone. In Argentina, Pettingill learned in 1978, Bobolinks were now being shot as pests for eating rice crops. It is not surprising that the number of breeding bobolinks has dropped by 75 percent in 25 years.

A new branch of science, studying the calls of nocturnal migrants to recognize individual species, was pioneered particularly by Bill Evans in 1985, who produced a cassette tape of the night calls of the thrushes. His compilations were joined by those of Michael O'Brien in 1991. Four years later they had "nailed down" the final two species that had eluded them, the night calls of Canada and Wilson's Warblers. By 2001, they produced the landmark guide that identified the flight calls of 211 species of migrating landbirds in eastern North America. Collaboration with researchers and software programmers at the Cornell Laboratory of Ornithology allowed analysis of different bird species from their individual characteristics. There are now thirty rooftop stations monitoring nocturnal migration with these new methods. Although Chu fails to list the Evans/O'Brien CD in her references, it became available in 2002 and can be ordered through http: oldbird.org.

Only in 1995 was Bicknell's Thrush recognized by the American Ornithologists' Union as a separate species from the similar Gray-cheeked Thrush. Chris Rimmer studied this thrush, one of the rarest migratory birds in North America, in its breeding habitat among the stunted firs near the top of Mount Mansfield in Vermont. But where did they winter? Rimmer's crew found them in the Sierra de Bahoruco in the Dominican Republic and, miracle of miracles, in 1995 captured in a mistnet one of the banded birds they had tagged in Vermont the previous summer – and then recaptured the same bird again in Vermont during the next two summers!

The reader is also given detailed directions to North American birding migration hotspots, in both spring and fall, and mid-winter hotspots in Yucatan, Belize, Costa Rica, and Panama. She provides instructions for amateurs to help contribute to knowledge, by partici-

pating in Nest Record Card programs and Project FeederWatch.

Chu concludes by calling attention to the many hazards facing bird populations, such as loss of habitat, increasing parasitism by cowbirds, deaths from striking windows, communication towers, pesticides, carbon dioxide emissions, and acid rain. Twenty-nine species have declined by more than fifty percent in the last 40 years. Despite these losses, the arrival of songbirds every spring remains a cause for celebration.

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BOTANY

Wildflowers of the Rocky Mountains

By G. Scotter and H. Flygare. Whitecap Books, 351 Lynn Avenue, North Vancouver, British Columbia V7J 2C4 Canada. 255 pages. $ 29.95 Paper.

Plants of Alberta

By F. Rover and R. Dickinson. 2007. Lone Pine Publishing. 10145 – 81 Avenue, Edmonton, Alberta T6E 1W9 Canada. 527 pages. $ 29.95 Paper.

It is most interesting that these two books have been published within such a short space of time. They were of immediate interest to me as I visit family in Alberta and usually manage a trip or two to the Rockies or the prairies. While they cover very different areas they include many of the same species. Furthermore, the authors have taken significantly different approaches.

Wildflowers of the Rocky Mountains [*Wildflowers*] contains 350 species of selected plants in six sections by flower colour [white, yellow and cream, green, pink, red, orange, and brown, purple and blue.] Each page depicts typically two species, all with a description, a photograph and a range map. The authors say they have chosen the most common species (typically the pretty species) likely to be encountered during visits to the Rockies, plus a few rarities. The area covered is the Rocky Mountain zone from northern British Columbia to New Mexico. This is a complete revision and expansion of a 1986 guide, that covered 228 species. The authors state that over the years they have learned to use non-technical language. They have been successful in applying this talent and has produced a very readable book.

I have a few problems with *Wildflowers*. I have a different view on the choice of colours. For example, I consider Mountain Sorrel to be reddish-brown not pink as the authors contend. Similarly, I think of Flame-coloured Lousewort (*Pedicularis flammea*) as red, but the authors have placed this plant in the cream section (because the flowers have a cream base). To further add to my confusion this plant is called Oeder's Lousewort (*P. oederi*) but *P. flammea* is given as the synonym. (However a web search of *P. oederi* showed images of cream-only flowers, while an image search for *P. flammae* showed cream-based flowers with significant amounts of red on the tips. A search for synonyms of *P. oederi* did not include *P. flammae*.) The alternative names are not included in the index. Many of the English, and some of the scientific names are not the ones I am used to. As an example, this book's Four-part Dwarf Gentian or Felwort is called Alpine Gentian in other texts.

The range maps are coloured in for the entire state or province regardless of how widespread the plant is. So Bear Grass is shown as occurring in Alberta, whereas it can only be found in the vicinity of Waterton Lakes National Park. This greatly reduces the usefulness of these maps.

I thought the approach used by *Wildflowers* – arranging the species by flower colour – was useful only for beginners. After a couple of years most people know the major families, like vetch, violet, saxifrage and so forth and I thought this is the way people progressed. Recently I was told that women prefer books organized by flower colour and I found my wife agreed.

The photographs are very good and will be useful in identifying blooms in the field. The descriptions in *Wildflowers* are written in prose, often in a poetic style that makes for pleasant reading. There is an excellent introduction on the eco-zones and a wonderfully clear glossary.

The second book is *Plants of Alberta* (*Plants*) which covers over 1500 native plants that can be found in Alberta. It is arranged by family and includes aquatic plants, grasses, ferns and trees (so not just the pretty flowers). Certainly I prefer the *Plants* method of arranging by families so I can reference all the orchids, violets, louseworts, etc. together. It too has a description, a photograph and a range map also shown two to a page. There is a short introduction and a decent glossary.

Plants' descriptions are cryptic and scientific. Compare "While other saxifrages may dress in flowers of white or yellow, Purple Mountain Saxifrage is garbed with flowers of the richest rose-purple to royal purple" (in *Wildflowers*) with the terse "Flowers: Purple (occasionally pinkish or white.)" (in *Plants*)

The photos in *Plants* average about twice the size of those in *Wildflowers* – a considerable benefit. This is achieved by having no margins, giving 20% extra space. Also the headers giving the plant names and family are 60% smaller [but less artistic!]. As the text is shorter the text size is bigger – great advantage for older eyes. The larger script comes at the loss of poetic text to terse notes. So despite the book's slightly smaller pager size (10%), by the creative use of space the publishers have created a more appealing looking book.

The range maps cover Alberta and show the area within the province where you can see the plant. This is useful because it shows over 35% of Alberta's species are confined to the southern border with British Columbia and the United States. As the maps are small (1 × 2 cm) they require some interpretation. I photographed a Striped Coralroot in Bow Valley Provincial Park, so I verified that the range map showed this plant at this location. It does, but it required careful examination and analysis due to the size. The other distributions are equally valid.

There is also a key arranged by leaf structure and flower colour. This uses thumbnail (¾") photos of the families. So *Violas* appear in the white, yellow and purple sections. Is this enough to satisfy the ladies?

Despite my clear preference for *Plants* as a book, I would say that both of these books are good guides. The photographs are excellent and the text, while very different in style, gives solid information. Your choice should be dictated by your intentions or location. Alternatively, and this I suggest is the best idea, you could buy both as both, are good value for money.

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MISCELLANEAOUS

Pilgrimage to Vallombrosa: From Vermont to Italy in the Footsteps of George Perkins Marsh

By John Elder. 2006. University of Virginia Press, Charlottesville, Virginia, USA. xv + 282 pages. U.S. $29.95 Cloth.

This book is a story of pilgrimage, of memory, of hope. It's a beautiful book, a book of life, of family, of nature and culture. John Elder, a professor of English at Vermont's Middlebury College, invites the reader on a pilgrimage. It is a story of connections; from the second and third growth sugar bush hills of Vermont to the centuries-old, culturally prestigious forests of Vallombrosa in the Tuscany hills; from the sugar bush to the olive grove; from Robert Frost to Dante.

Vermont-born George Perkins Marsh was Abraham Lincoln's diplomat to the new Kingdom of Italy from 1861 until his death in 1882. Considered to be America's first environmentalist, Marsh was the author of the celebrated *Man and Nature* (1864). Inspired by his study of the rise and fall of Mediterranean cultures and his extensive experience of the region, Marsh's manifesto focused on environmental decline as central to the collapse of these once powerful cultures. Marsh was the first to describe and document the drastic, long-term impact of deforestation on civilization. His *Man and Nature* stirred the American imagination as America itself experienced the wave of deforestation flowing from east to west across the American landscape.

A sabbatical year permitted Elder and his wife to set out on a pilgrimage across France and Italy. Elder's purpose was to pursue the footsteps of Marsh who died in Vallombrosa in 1882. A pilgrimage usually has a set route, but novelty and surprise are to be expected. A pilgrimage on foot always becomes a pilgrimage of the heart and of the mind. Elder skillfully invites the reader on a pilgrimage of ideas, one that examines our place in nature.

Elder divides his pilgrimage into three landscapes, each connected to Marsh's vision of conservation. First is the journey to and within Tuscany, the crucible of Marsh's thinking in the city of Florence, the surrounding hill towns and the celebrated forests of Vallombrosa. Second, is the literary landscape where Elder situates Marsh within the lineage of William Wordsworth, Matsuo Bashô and Robert Frost. The final section returns to Vermont, to Marsh's native Woodstock, the sugar bush of the Elder family, and to the Vermont-wide conservation initiatives.

Those who set out on a pilgrimage usually have a destination in mind. But that is often the only sure thing about a pilgrimage. It's what happens in between that counts and that often surprises. Nothing is hard and fast for Elder, nothing black-or-white. He writes skillfully of what he terms the "middle landscape," that ecotone where wilderness and civilization meet. It is upon that middle ground that Elder chooses to focus, weaving the theme of "stewardship" throughout his work.

The term "stewardship" has fallen on hard times in certain intellectual circles. Its anthropocentric connotations are too aristocratic, too old-fashioned for some. Not so for Elder, who calls for a mutuality of human history and natural history. He calls for preservation of not only biodiversity but also human values and community, a place where technology and religious faith both have their own special role to play. For Elder, the environmental crisis is ultimately a crisis of culture, a crisis of the human soul, a crisis of the human heart. Stewardship, brought into proper dialogue with contemporary ecological, feminist, religious and social justice thought, can engender the cultural and moral resources necessary to address the environmental needs of our time.

Elder's attempt to re-frame the discussion is welcome. Too often has environmental conversation fractured into dualistic dichotomies, into opposing camps of nature and culture. We need both voices to forge a social ecology, where ecosystems are not considered in the absence of culture and vice-versa. It's that middle ground that provides the vital connection between

remote regions of wilderness and the places were we live, work and play.

We must thank Elder for eschewing sectarian language. His goal takes much more effort. It seeks a common ground that does not reduce to the lowest common denominator. The built environment, the cultivated environment, the wilderness environment; they all have a voice that needs to be heard. Elder speaks in the tradition of Aldo Leopold, René Dubos and Wendell Berry, voices that seek a dialogue between culture and the wild. For all three, the steward is the facilitator of such a needed task. The steward lives in that "boundary zone where the wilderness ethic may engage with recent developments of environmental history, and where the ideal of preservation transcending our narrow utilitarianism may engage with the tradition of stewardship." (page 218)

This is marvellous meditation. It's no wonder, since Elder's trade and tackle are words and stories. He weaves a story, a meditation, a contemplation that opens up our mind and heart to new possibilities for our relationship to forests, to those wild and wonderful places. It is a story of people tending the olive groves under the warm Tuscany sun, and of his own family's stewarding of the sugar maple groves of their Vermont home. Landscape and culture provide the nexus of discussion. Forgetting one or the other dehumanizes us and sets the stage for either pillage or misanthropism.

In this era of apocalyptic predictions, environmental and social haemorrhaging, a widening gap between culture and nature, between rich and poor, urban and rural, Elder sets out a path of reconciliation, a path that seeks the common good. It's a path laced with community, dialogue, a sense of the sacred, good work, justice, stewardship, care and respect. These virtues don't come easily.

A final word to Elder: "I have come to believe that without the stories that integrate the face of nature with the drama of our human lives, society will not have the power to restrain our appetite and respect the larger balance of nature." (page 67) If you accept this conclusion, read this book. It will draw you into a world of memory and elegance. If you don't agree with Elder, read this book anyway. The full, inclusive fare offered by Elder will call you into a respectful dialogue.

JOHN MCCARTHY

Ecology Project, Ignatius Jesuit Centre of Guelph, P.O. Box 1238, Guelph, Ontario N1H 6N6 Canada

Where to Watch Birds – World Cities

By Paul Milne. 2007. Yale University Press P.O. Box 209040, New Haven, Connecticut 06520-9040 USA. 496 pages. U.S. 28.00 Paper.

This type of book is a reviewer's dream. Before you open it you know the author, Paul Milne, must make choices and these will not be the same as your choices. This means you know you will have the opportunity to criticize. So how well do his choices match those I would have made? First he has included only one Canadian city, Toronto. It is Canada's largest city but it is not the capital nor the best for the naturalist. One out of the 60 cities covered in the book seems a little thin for second largest country in the world [even if we rank 36th for population]. Putting my obvious bias aside, I noted that other key cities are missing. Oslo, with its great royal park, and Kiev, a city of wonderful chestnut trees, are two evident examples. Indeed 60% of the cities are in Europe and Asia; a disproportionate number for these two continents over North and South America and Australia.

Accepting the author's choices, how useful is this book? First this book covers more than the city itself. When I visit Victoria, British Columbia, I get up at dawn and walk from my downtown hotel through Beacon Hill park to the coast. I return before breakfast and then go to my meeting. These two hour jaunts have netted me some very interesting birds [e.g. Ancient Murrelet]. These activities were all within the downtown core of Victoria and did not involve any travel. The author includes in his version of "city" many areas that require significant travel – you will need a car. The equivalent of me driving to Goldstream Park, 17 kilometres from downtown Victoria, and more. Indeed some sites are over 100 km away (distances are given in the measurement used in the country; e.g., they are in miles in the U.S. and kilometres in Canada.)

Accepting the author's broad boundaries how useful is this book? I would say very useful indeed. I have birded in almost half of the cities mentioned [generally without a car] and have visited many of the sites he describes. He has an introductory section that explains the city in birder's terms and has a good section on transportation. Where there is a good public transportation to suitable birding locations (e.g., London, Moscow) the author provides enough information to get the traveller started. The site descriptions are clear and accurate and I wish I had owned this book years ago. There are locator maps where they are appropriate. There is a list of birds typically seen at each location. This worked well for all places and I verified with my notes that I too had seen a similar list of species.

I can quibble on some minor points. For example, under Johannesburg he includes Suikerbosrand [upland species – about 70 km from Johannesburg] but omits the nearby Pilansburg – perhaps the best park to visit [lowland species – about 100+ km from Johannesburg]. His information on travel omits to say it would be almost suicidal for a tourist to drive in Mumbai. Taxis are cheap and you can get a car and driver, sympathetic to your needs, from the Bombay Natural His-

tory Society for reasonable cost. If you take a photo booth shot of yourself plus a glue stick to Austria, you can get a multi-day pass to Vienna's excellent public transit; a most economical way to travel.

All in all this is a great and useful book. My next trips are to Halifax and then Anchorage, but neither of these is included by the author. However, I look forward to using it on my next trip to one of the cities in this book, which will likely be Moscow. I would encourage Paul Milne to travel more in North and South America. Then I can hope he plans a second volume to cover some of the cities he has missed.

ROY JOHN

2193 Emard Crescent, Beacon Hill North, Ottawa, Ontario K1J 6K5 Canada

Marshes: The Disappearing Edens

By W. Burt. 2007. Yale University Press, P.O. Box 209040 New Haven, Connecticut 06520-9040 USA. 192 pages. U.S. 35.00 Cloth.

William Burt has a very deserved reputation. His photographs are amazing. As a naturalist who also takes photos I have some idea of the skill and the patience needed to get a good shot. Burt goes beyond good. Not only are the photos amazing in their quality, but he specialises in birds that are typically difficult to see! Take Black Rail as an example. I spent several hours at night wading in a swamp with an ardent group of seekers before I had my first glimpse of a Black Rail. It ran over my foot. It took another hour to actually get my binoculars [and flashlight] on one of the cute but elusive beasts. The idea of a photograph never entered my head. I do have some slides of other rail species I took mostly by good luck. They are nice, but they are not artistic and they all have little flaws. Burt's photos are technically crisp and clear. They are also artistic; the kind you would frame and hang on the wall.

In addition to birds, the author has also included a number of pictures of marsh vegetation and some of the more picturesque flowers. Actually this book is over 50% photographs.

Once you have finished drooling over the illustrations you could read the text. The author describes his visits to wetlands throughout North America. Starting with his home base in Connecticut river marshes he travels to Maryland (Elliot Island), Manitoba (Sewall Lake), Saskatchewan (Crane Lake), Oregon (Malheur) and California (Klamath). He also takes us on a trip through wetlands in Texas, Louisiana, Florida and Virginia. At each site he describes the value that each place brings and some of the issues it now faces.

Burt make an emotional, almost poetic appeal for marshes. He describes his favourite haunts along the east coast of the United States with such verve that I realised, somewhat for the first, that I too had experienced the same feelings. I tend to look at life more clinically, but Burt is more passionate and has shown that I have similar emotions to him below the surface.

I believe you should learn something new every day. I began to learn as soon as I started to read. For the first time I properly understand the issue with *Phragmites*. The ones I see are more likely the aggressive – and therefore dangerous – European plant and not the look-alike native version. Alien invaders are a key threat and *Phragmites* and loosestrife lead that charge.

His description of the work of the photographers Walter Finley and Herman Bohlman in the 1800s is enlightening on the persistence and dedication of these pioneers plus their resounding contribution to conservation.

This a lovely book and would make a wonderful present for both naturalists and non-naturalists. The beautiful writing style and powerful messages might even convert some folks to be conservationists.

ROY JOHN

2193 Emard Crescent, Beacon Hill North, Ottawa, Ontario, K1J 6K5 Canada

NEW TITLES

Prepared by Roy John

†Available for review * Assigned

ZOOLOGY

Albatrosses, Petrels and Shearwaters of the world. By D. Onley and P. Scofield. 2007. Yale University Press, P.O. Box 209040, New Haven, Connecticutt 06520-9040 [North America] or Christopher Helm Publishers Ltd./A&C Black Publishers Ltd., 38 Soho Square, London W1D 3HB [Europe and the Commonwealth]. 256 pages. U.S. $29.95.

Catalogue of Aleocharine Rove Beetles of Canada and Alaska (Coleoptera, Staphylinidae, Aleocharine). By N. Gouix and J. Klimaszewski. Pensoft Publishers, Geo Milev Street 13a, 1111 Sofia, Bulgaria. 166 pages. EURO 60 hardback.

Atlas of Bird Migration. Edited by J. Elphick. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 176 pages. $35.

An Enchantment of Birds. By R. Cannings. 2007. Greystone Books, #201 – 2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 211 pages. $29.95.

Aves amenazadas de Espana. By J. Varela. [In Spanish]. 2007. Lynx Edicions, Passeig de Gràcia, 12, 4rt. 2a, 08007 Barcelona, Spain. 325 pages. U.S. $38.40.

The Lapwing. By Michael Shrubb. 2007. T & AD Poyser (A&C Black Publishers Ltd, 38 Soho Square, London W1D 3HB). 320 pages. $100 (approximately).

Lista Comentada de las Aves de Guatamala – Annotated Checklist of Birds of Guatamala [bilingual English Spanish]. By K. Eiserman and C. Avendano. Lynx Edicions, Passeig de Gràcia, 12, 4rt. 2a, 08007 Barcelona, Spain. U.S. $15.60

*** The Birder's Companion.** By Stephen Moss. 2007. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 239 pages.

All the Birds of Brazil – An Identification Guide. Second Edition. By D. De Souza. 2006. Editora Dall/Subbuteo Natural History Books, The Rea, Upton Magna, Shrewsbury SY4 4UR UK. 325 pages. U.S.$60.

500 Butterflies. By K. Preston-Mafham. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 528 pages. $29.95 Cloth.

Ecology and Behaviour of Chickadees and Titmice. Edited by K. Otter. 2007. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 352 pages. U.S. $102. Cloth.

***Deep Alberta – Fossil Facts and Dinosaur Digs.** By John Acorn. 2007. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Canada. 186 pages. $26.95 Paper.

*** Ladybugs of Alberta.** By J. Acorn. 2007. University of Alberta Press Ring House 2, Edmonton, Alberta T6G 2E1 Canada. $ 29.95

Lost Land of the Dodo. By A. Cheke and J. Hume. 2007. Christopher Helm Publishers Ltd./A&C Black Publishers Ltd., 38 Soho Square, London W1D 3HB. 504 pages. U.S. $84.

300 Frogs. By C. Mattison. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 528 pages. $29.95 Cloth.

Pocket Guide to the Insects of Britain and Western Europe. By M Chinery. 2007. Christopher Helm Publishers Ltd./ A&C Black Publishers Ltd, 38 Soho Square, London W1D 3HB UK. 320 pages. U.S. $26.20.

The Red Kite. By I. Carter. 2007. Arlequin Press, The Rea, Upton Magna, Shrewsbury SY4 4UR U.K. 200 pages. U.S. $44. Cloth.

The Lepidoptera of Israel. Volume II: Noctuidae. By V. D. Kravchenko, M. Fibiger, A. Hausmann and G. C. Mueller. 2007. Pensoft Publishers, Geo Milev Street 13a, 1111 Sofia, Bulgaria. In English, 320 pages. EURO 110. Hardback.

Where to Watch Mammals in Britain and Ireland. By R. Moores. 2007. Christopher Helm Publishers Ltd./A&C Black Publishers Ltd, 38 Soho Square, London W1D 3HB U.K. 304 pages. U.S. $29.60. Paper.

Manipulative Monkeys – the Capuchins of Lomas Barbudal. By S. Perry and J. Manson. 2007. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 326 pages. U.S. $45.

A Field Guide to New Zealand Birds. By B. Parkinson. 2007. New Holland Publishers (UK) Ltd., Garfield House, 86-88 Edgware Road, London W2 2EA U.K. 136 pages. U.S. $22.75.

Know Your New Zealand Birds. By L. Moon. 2007. New Holland Publishers (UK) Ltd., Garfield House, 86-88 Edgware Road, London W2 2EA U.K. 126 pages. U.S. $22.75.

Collins Field Guides – Birds of the Palearctic: Passerines. By N. Arlott. 2007. Harper Collins Publishers Ltd., 2 Bloor Street East, 20th Floor, Toronto, Ontario M4W 1A8 Canada. 384 pages. U.S $46.

Photographic Guide: Birds of Peru. By C. Byers. 2007. New Holland Publishers (UK) Ltd., Garfield House, 86-88 Edgware Road, London W2 2EA U.K. 144 pages. U.S. $15.95.

The Sand Wasps – Natural History and Behavior. By H. Evans and K. O'Neill. 2007. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 340 pages.

† At Sea Distribution and Abundance of Seabirds off Southern California: A 20 Year Comparison. Studies in Avian Biology Number 33. By J. Mason et al. Cooper Ornithological Society, c/o Western Foundation of Vertebrate Zoology, 439 Calle San Pablo, Camarillo, California 933012-8506 USA. 101 pages. U.S. $15.

Sharks of the Pacific Northwest. By A. De Maddalena, A. Preti and T. Polansky. 2007. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 160 pages. $21.95 Paper.

The Smaller Majority. (Insects) By P. Nasrecki. 2007. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 288 pages. U.S. $24.95.

The Birds of Thai-Malay Peninsula – Volume 2. By D. Wells. 2007. Christopher Helm Publishers Ltd./A&C Black Publishers Ltd, 38 Soho Square, London W1D 3HB U.K. 704 pages. U.S. $120.

Oceanic Wilderness. By Roger Steene. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 340 pages. $59.95 Cloth.

Shells. By P. Starosta and J. Senders. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 384 pages. $85. Cloth.

Whales and Dolphins of the North American Pacific. By G. Cresswell, D. Walker and T. Pusser. 2007. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 216 pages. $21.95 Paper.

BOTANY

*** Plants of Alberta.** By F. Rover and R. Dickinson. 2007. Lone Pine Publishing. 10145 – 81 Avenue, Edmonton, Alberta T6E 1W9 Canada. 527 pages. $ 29.95. Paper.

Comparative Plant Ecology. J. Grime, J. Hodgson and R. Hunt. 2007. Springer Science+Business Media Deutschland GmbH, Heidelberger Platz 3, 14197 Berlin, Germany. 752 pages. $168. Cloth.

Pocket Guide to the Trees of Britain and Northern Europe. By A Mitchel. 2007. Christopher Helm Publishers Ltd./A&C Black Publishers Ltd, 38 Soho Square, London W1D 3HB U.K. 288 pages. U.S. $26.20

*** Wild Flowers of the Rocky Mountains.** By G. Scotter and H. Flygar. 2007. Whitecap Books Ltd, 351 Lynn Avenue, North Vancouver. British Columbia V7J 2C4 Canada. 255 pages. Illustrations $29.95.

OTHER

Digital Wildlife Photography. By D. Tipling. 2007. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 160 pages. $24.95 paper.

Drawing and Painting Plants. By Christina Brodie. 2007. Timber Press, 133 SW 2nd Avenue, Ste. 450, Portland, Oregon, USA. 144 pages. C$27.95. Paper.

Where to Watch Birds in Donana. By F. Chiclana and J Garzon. 2006. Lynx Edicions, Passeig de Gràcia, 12, 4rt. 2a, 08007 Barcelona, Spain. 160 pages. U.S. $28.

*** Gilbert White.** By Richard Mabey. 2007. University of Virginia Press, P.O. Box 400318, Charlottesville, Virginia 22904-4318 USA. 230 pages.

Hispaniola. Edited by E. Fernandez. 2007. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 400 pages. U.S. $60.

*** Pioneering Conservation in Alaska.** By Ken Ross. 2007. University Press of Colorado, 5589 Arapahoe Avenue, Suite 206C, Boulder, Colorado 80303 USA. 540 pages. $34.95. Cloth.

This Tender Place – The Story of a Wetland Year. By Laurie Lawlor. 2007. The University of Wisconsin Press, 1930 Monroe Street, Third Floor, Madison, Wisconsin 53711-2059 USA. 166 pages. U.S. $19.95. Paper.

*** Marshes: The Disappearing Eden.** By W Burt. 2007. Yale University Press P.O. Box 209040New Haven, Connecticut 06520-9040 USA. 192 pages. U.S. $35.

Oregon's Dry Side – Exploring East of the Cascade Crest. By Alan D. St. John. 2007. Timber Press, 133 SW 2nd Avenue, Ste. 450, Portland, Oregon 97204 USA . 324 pages. U.S. $29.95.

The Ornithologist's Dictionary. By J. Erritzoe, K. Kampp, K. Winker and C. Frith. 2007. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. U.S. $25. Paper.

*** A Paddlers' Guide to Quetico and Beyond.** By K. Callan. 2007. Firefly Books, 132 Main Street, Erin, Ontario N0B 1T0 Canada. 192 pages. $ 24.95.

Intelligent Courage: Natural Resource Careers that Make a Difference. By M. Fraideburg. 2007. Krieger Publishing Company, P.O. Box 9542, Melbourne, Florida 32902-9542 USA. 220 pages. U.S. $32.50.

YOUNG NATURALISTS

*** Gracie, the Public Gardens Duck.** By Judith Meyrick. 2007. Nimbus Publishing, 3731 Mackintosh Street, Halifax, Nova Scotia B3K 5A5 Canada. 32 pages. $16.95.

News and Comment

Marine Turtle Newsletter (113)

July 2006. 24 pages: EDITORIAL: New editors for MTN — ARTICLES: Hawksbill and Olive Ridley nesting on Masirah Island, Sultanate of Oman: an update (A. F. Rees and S. L. Baker) — Preliminary data from an increasing Olive Ridley population in Sergipe, Brazil (J. C. Castilhos and M. Tiwari) — NOTES: First report of Green and Kemp's Ridley Turtle nesting on Wassaw, Georgia, USA (K. L. Williams, M. G. Frick, and J. B. Pfaller) — LETTERS — MEETING REPORTS — MST UPDATE — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Brendan J. Godley and Annette C. Broderick, Marine Turtle Research Group, Centre for Ecology and Conservation, University of Exeter in Cornwall, Tremough Campus, Penryn TR10 9EZ United Kingdom; e-mail MTN@seaturtle.org; Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at <www.seaturtle.org/mtn> or postal mail to Michael Coyne (online Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

The Boreal Dip Net/L'Epuisette Borèale January 2006

Newsletter of the Canadian Amphibian and Reptile Conservation Network (CARCNET) 10(1). CONTENTS: Editor's Note — Faces and Places/In the Bag — Snake habitat manipulation — A request for information — CARCNET field trip — Natural Heritage Building of the Canadian Museum of Nature & Parc de la Gatineau, QC — Presentations made at the 2005 annual meeting of CARCNET/RECCAR — Reintroduction of Leopard Frogs at Bummer's Flats — Northern Leopard release marks fifth year — Lost Leopard? — A significant range extension for the Northern Alligator Lizard in British Columbia — Faces and Places/Out of the bag.

Membership information can be obtained from Bruce D. Pauli, Canadian Wildlife Service, National Wildlife Research Centre, Carleton University, Raven Road, Ottawa, Ontario K1A 0H3 Canada. Additional information is at website http://www.carcnet.ca.

Minutes of the 127th Annual Business Meeting of The Ottawa Field-Naturalists' Club 10 January 2006

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:30 p.m.
Chairperson: Mike Murphy, President
Attendance: Forty-two persons attended the meeting.

Attendees spent the first half-hour reviewing the minutes of the previous meeting, the Treasurer's report and the Report of Council. The meeting was called to order at 7:40 p.m. with some opening remarks from the President.

1. Minutes of the Previous Meeting

Under Report of the Nominating Committee/Committee Chairs: The Chair of the Education and Publicity Committee should be corrected to read Gillian Marston not John Cameron.

It was moved by Gillian Marston seconded by Fenja Brodo that the minutes be accepted.

(Motion Carried)

2. Business Arising from the Minutes

There was no business arising from the Minutes.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report

Frank Pope reviewed the financial report for the year ending 30 September 2005, noting that the Club's net assets had increased by approximately $86,350. This was due in large part to a bequest from the estate of Mildred Groh of $62,250. There was an amendment to the Report.

Moved by Frank Pope and seconded by Diane Lepage that the Financial Report be accepted as amended.

(Motion Carried)

5. Committee Reports

Mike Murphy introduced each of the Committee reports and a representative of the appropriate Committee and asked for questions and comments. He thanked the committee chairs and committee members for their work over the previous year.

Moved by David Hobden seconded by Gillian Marston, that the reports be accepted with suggested amendments.

(Motion Carried)

6. Nomination of the Auditor

Moved by Frank Pope, seconded by Bill Cody, that Janet Gehr continue as Auditor for another year.

(Motion Carried)

7. Report of the Nominating Committee

President	Mike Murphy
Vice President	Ken Allison
Secretary	Susan Laurie-Bourque
Treasurer	Frank Pope
Past President	Gary McNulty
Business Manager	Bill Cody
Editor, CFN	Francis Cook
Editor, T&L	Karen McLachlan Hamilton

Committee Chairs

Birds	Chris Traynor
Computers	Dan Millar
Conservation	Stan Rosenbaum
E&P	Gillian Marston
E&L	Fenja Brodo
Finance	Ann MacKenzie
FWG	David Hobden
Macoun rep.	Diane Kitching
Membership	Henry Steger
Publications	Ron Bedford
ON Rep	Eleanor Zurbrigg

Members at large
Susan Howell
Julia Cipriani
Justin Peter

Chairs not on Council

Awards	Ernie Brodo
Macoun	Rob Lee
Nominations	Fenja Brodo

Retiring from the council: Kathy Conlan, Louise Schwartz, Dave Smythe

New on the council: Ken Allison, Julia Cipriani, Susan Howell, Ann MacKenzie, Dan Millar and Justin Peter.

Moved by Fenja Brodo, seconded by Frank Pope, that the slate of nominations for the 2006 Council be accepted.

(Motion Carried)

8. New Business

There was no new business.

9. Presentation of Awards for the 2005 OFNC Photo Contest

There was a presentation of the awards to the winners of the 2005 OFNC Photo Contest by Suzanne Deschene and Gillian Marston. The grand prize winner received a digital camera and photo printer.

Amphibians:	Ruth Allison
Birds:	Lois Naggs
Insects and spiders:	Christine Hanrahan
Mammals and vegetation:	Jim Robertson
Scenery:	Stephen Darbyshire
Honorable mention –	
Birds and vegetation:	Gwen Williams
Grand prize winner:	Dave Sankster

The Education and Publicity committee was already planning the next photo contest, tentatively titled "The Tale of the Trail". Details to be published in *Trail & Landscape*.

The presentation of the awards was followed by a slide show of the contest entries. This was viewed with admiration and enjoyment by the members in attendance.

10. Adjournment

Moved by Henry Steger/Ron Bedford that the meeting be adjourned at 9:35 pm.

(Motion Carried)

SUSAN LAURIE-BOURQUE
Recording Secretary

The Ottawa Field-Naturalists' Club Committee Reports for 2005

Awards Committee

At the club's Annual Soirée, on 30 April 2005 at St. Basil's Church in Ottawa, awards were once again given to members, and two non-members, who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary activity within the club. There isn't always a winner for every potential award, and this year, once again, the Anne Hanes Natural History Award was not given. On the other hand, a new award was approved by Council and awarded for the first time this year: the Mary Stuart Education Award. This new award has been established for members, non-members or organizations in recognition of outstanding achievements in the field of natural history education in the Ottawa Region. The new Education Award was appropriately named in honour of Mary Stuart, who was so passionately interested in establishing a new generation of young naturalists. The winners of the 2004 Awards were:

HONORARY MEMBER:

Charles D. Bird – a long-time member of the OFNC and one of Canada's most outstanding naturalists in the fields of cryptogamic botany and entomology. He has been an associate editor of *The Canadian Field-Naturalist* for over 25 years.

MEMBER OF THE YEAR:

Marilyn Ward – for her efforts in handling the club phone, helping to make sure lecture and excursion events are successful, and keeping the Fletcher Wildlife Garden spic and span.

GEORGE MCGEE SERVICE AWARD:

Martha Camfield – for her many years of service with the Macoun Field Club both at meetings and in the field, and for her botanical work on the Leitrim wetlands.

MARY STUART EDUCATION AWARD:

Andrea Howard – for her extraordinary, innovative work in teaching natural history at the Eastern Ontario Biodiversity Museum in Kemptville and her "Museum in a Suitcase" school programs.

CONSERVATION AWARD – MEMBER:

Ghislaine Rozon – for her extraordinary efforts in trying to save the Larose Forest from destruction by developers.

CONSERVATION AWARD – NON-MEMBER:

Barbara Barr – for attending municipal and regional meetings and hearings regularly, mostly representing the Greenspace Alliance, gathering information, presenting briefs, and being a source of sage advice to policy makers on conservation issues.

The full text of the citations for each of these awards was read at the annual soirée and will be published in vol. 119, no. 4 of *The Canadian Field-Naturalist*.

IRWIN BRODO
Chair, Awards Committee

Birds Committee

The Birds Committee participated with the Club des Ornithologues de l'Outaouais in both the Christmas Bird Count and the Fall Bird Count. The compilation dinners for both events were very well attended. The committee again organized the Peregrine Falcon Watch at the nest site downtown. Donations to the watch in 2005 totalled $275. While both chicks fledged, one disappeared and its fate remains unknown. Sadly, the adult female, Horizon, was injured and subsequently euthanized at the request of the Ministry of Natural Resources. We continued to provide seasonal bird summaries for *Trail & Landscape*. Several members have also enhanced our committee's presence on the OFNC's web site. The 5th and final year of the Ontario Breeding Bird Atlas has been completed and a report summary has been prepared. The Bird Record Sub-committee met several times during the year to review rare bird records. The committee also provided several leaders for OFNC bird trips. The committee has also added a new bird feeder, provided by the National Capital Commission, near the new picnic shelter at the Mer Bleu. The 2005 seed-a-thon raised over $300 in pledges. We continue to operate the rare bird alert and Ottawa's bird status line which provides updates and information on both rare birds and regular report summaries.

CHRIS TRAYNOR
Chair, Birds Committee

Computer Management Committee

During 2005, the Club purchased two new computers, one for use by the Treasurer's Assistant; old equipment has been retired.

The Computer Management Committee reviewed how club volunteers manage key information holdings of the club, to ensure that club data are secure and accessible. Key files include the membership database, financial records, *Trail & Landscape* electronic archives, and *Canadian Field-Naturalist* files. The committee concluded that current data management practices are adequate.

There were no requests to the Computer Management Committee from other committees during the year for computer support, as they had expertise available in-house.

The club upgraded the capabilities of its web site considerably when it moved to a new service provider. These improvements are allowing the Web Master to continue to improve the content of our popular web site.

ELEANOR ZURBRIGG
Chair, Computer Management Committee

Conservation Committee

Alfred Bog

Frank Pope continues to chair the Alfred Bog Committee, while planning to hand over to a new person who has provisionally accepted this position.

Planning Reform

In follow-up to our 2004 brief and letters to Ontario Ministers, additional letters were sent on 19 May 2005, including a joint letter to the Premier and four Ministers, and individual covering letters to each. Frank Pope and Eleanor Zurbrigg presented our position on planning reform at the Ontario Nature/Federation of Ontario Naturalists regional meeting at Alfred College on 15 October. A meeting to discuss the issues with the ON/FON regional Board Member was set for 6 December.

South Gloucester (5309 Bank Street)

We sent notification by registered letter to both the Ministry of Natural Resources and R. W. Tomlinson, stating our continuing opposition to the granting of an aggregate extraction licence to which we had previously objected. We pointed out that R. W. Tomlinson's proposed mitigation measures for damage to significant plant species were dismissed in short work by Brunton Consulting Services in a second Peer Review specially ordered by the City. The issue was presently on hold pending hearings at the Ontario Municipal Board of appeals by the Greenspace Alliance and others.

Pesticide Use on Lawns and Gardens

Email letters were sent to the Mayor of Ottawa and Councillors, supporting a campaign that is trying to get the present (ineffective) policy of voluntary reduction in pesticide use replaced by a ban on the cosmetic use of pesticides. City Council rejected a ban, but the Mayor and some Councillors in favour of a ban stated that they would make this an election issue in 2006.

STAN ROSENBAUM
Chair, Conservation Committee

Education and Publicity Committee

KIOSKS, DISPLAYS AND OTHER EVENTS

The committee enhanced the material available for displays and kiosks by adding several light weight portable displays. Committee members participated with displays at the Ottawa-Carleton Elementary Teachers' Federation Publishers' Display, National Wildlife Week's Wildlife Festival, Environment Week Fair and Eco Fair at Friends of the Farm and the OFNC Soirée. Once again the OFNC participated in the Ottawa Science Fair sponsoring a prize for a project judged by Education and Publicity Committee member Kathy Conlan. The committee also arranged speakers for outside groups.

OFNC MEMBERSHIP DRIVE

The portable kiosks were used for approximately 10 outings for a successful spring club membership drive

DIGITAL LIBRARY

The committee has initiated the OFNC's 'digital photo library and catalogue' as a successor to the slide collection that the committee currently manages.

OFNC NATURE PHOTOGRAPHY CONTEST

The committee ran a members' photography contest to encourage discovery of nature and enhance the club's digital library. Over 200 entries were received and catalogued in the digital photo library.

BROCHURES

The committee continued to distribute the club brochure to area libraries and nature shops.

GILLIAN MARSTON
Chair, Education and Publicity Committee

Executive Committee

No report

Excursions and Lectures Committee

In 2005 this committee arranged 29 events, ten monthly meetings (including the Annual Business Meeting) plus the Soirée. The majority of our trips (twelve) were of general interest, two were devoted to plants, two to geology, four to mammals and invertebrates and nine were birding trips. The latter included our club's biannual bus trip to Pt. Pelee which was very well attended, and two winter birding trips in conjunction with the Kingston Field-Naturalists Club. There have been fewer birding trips the last five years because potential leaders were heavily involved with the Breeding Bird Atlas.

Something new in 2005 was a winter wildlife tracking excursion, on snowshoes, in the Gatineau. Also a first, club members were invited to join members of the Dragonfly Society of America, meeting in Amprior, on their scheduled field trips. Unfortunately a woodworking workshop had to be cancelled for lack of interest.

Our policy remains to arrange meeting places that are accessible by bus. The signed waiver forms allow us to track the popularity of events and help leaders to recognize participants.

Our monthly meetings cover a great diversity of subjects and most of our speakers are OFNC members.

FENJA BRODO
Chair, Excursions and Lectures Committee

Finance Committee

The Finance Committee met four times in 2005. Highlights include:

1. Increase in membership fees for the calendar year 2007

Fees had not been increased for at least four years, and some concerns were noted about gradually declining membership and operating deficits experienced over the previous few years. The committee recommended to Council that fees not be increased for calendar year 2006, but that the membership fees increase by at least $5 in 2007. These recommendations were approved by OFNC Council.

2. Meeting with the OFNC Auditor

The Treasurer, Frank Pope, and the Chair of the Finance Committee met with the OFNC Auditor, Janet Gehr. She advised that the financial health of the club was good compared to similar non-profit organizations and that we had ample reserves. She also advised that our computer hardware and software were adequate, as well as the club's record keeping and documentation. It was recommended that future financial statements include a note on potential liabilities related to the backlog of publication of the *Canadian Field-Naturalist*. The amount of deferred revenue which would cover a part of this financial commitment should also be noted. This recommendation was acted upon by the Treasurer.

3. Budget for 2005-06 Fiscal Year

A proposed budget for the OFNC and the *Canadian Field-Naturalist* for the period 1 October 2005 to 30 September 2006 was submitted to Council. A deficit of over $18,000 was forecast, and if realized would be a draw on the unrestricted reserve. Council approved this proposed budget.

4. Other Items

During the year the committee discussed the impact of changes in the federal government's Publication Assistance Program on mailing costs for *The Canadian Field-Naturalist* and *Trail & Landscape*, the increase to the audit fee from $1,000 to $2,000, a credit card for club business (not approved), the bequest from the estate of M. Groh, and reviewed the draft financial statements for 2004-05 before finalization.

LOUISE SCHWARTZ
Chair, Finance Committee

Fletcher Wildlife Garden Committee

The Garden completed another successful year with over 2000 volunteer hours contributed. We held or participated in a number of events. In February, it was the Great Backyard Bird Count and then an information table at the Pesticides Conference. April brought the Wildlife Festival with a display at Billings Bridge Shopping Centre, joint sponsorship of a seminar at the Canadian Museum of Nature and an event at our Centre for Annual Migratory Bird Day. Our annual plant sale in June raised over $2000. We also participated in a Central Experimental Farm Open House held in September.

Without a grant we were only able to have a part-time employee who worked on the interpretation program. Our preferred employee was unable to start immediately, so the program began later and ran through September.

Remodelling of the Backyard Garden continued. Some beds have been reshaped, a new entrance sign added and the patio re-laid. In 2006 most of the beds will contain only regional native flowers.

Our work on invasive plants continues. There is some success with buckthorn and garlic mustard, but swallow-wort continues to be a problem. All methods of removing it end up destroying everything else as well. We are also working on burdock, Canada thistle and amur maple which have become too common. Flowering rush and cat-tails are being removed from the pond. The pond itself is showing decreased biodiversity with very few insect larvae observed in 2005. The primary water source is agricultural run-off so this trend may be difficult to reverse.

In the spring we published a new general brochure in English, using a grant from TD Friends of the Environment Foundation and intend to seek another grant to publish the French version. Information sheets on burdock and garlic mustard were also produced. For the Central Experimental Farm Open House a bilingual miniguide was prepared to give an overview of what the Fletcher Wildlife Garden has to offer. This is now available to all visitors.

We have renewed the main entrance sign, enhanced the boundary sign system and the direction signs along the Bill Holland Trail. Other improvements include a small shed and gravel on heavily used parts of the trail system. During the winter there was considerable rabbit damage. We must expect this problem to continue until the local fox population recovers.

DAVID HOBDEN
Chair, Fletcher Wildlife Garden Committee

Macoun Club Committee

The committee met once during the year, with most of the planning being coordinated by telephone and e-mail. Committee members supervised or gave presentations at 18 indoor meetings (down from 44 last year) and led 14 field trips and one camping trip (roughly the same).

The much reduced number of meetings stems from the failure of a Senior (high-school-age) group to form this year, apparently for the first time in the Club's 57-year history. In part, this follows from weak participation over a period of years in the Intermediate (middle-school) group, which would normally feed into the Seniors. But it also appears to be a social phenomenon of a proliferation of competing activities, and ever more tightly scheduled lives.

Participation in the Junior group remains strong, although the same social pressures have become evident in the families of younger children, too. With no Senior members, the Macoun Field Club's annual publication (*The Little Bear*) had to be edited and produced by a committee member for the first time since 1988. The content, however, continues to be dominated by the children's work.

ROBERT E. LEE
Chair, Macoun Club Committee

Type	Canadian				Foreign				Total	
	Local		Other		USA		Other			
Family	312	(301)	23	(19)	2	(1)	1	(1)	338	(322)
Individual	307	(310)	101	(107)	18	(19)	5	(4)	431	(440)
Honorary	14	(14)	11	(10)	0	(0)	0	(0)	25	(24)
Life	21	(21)	20	(20)	7	(6)	1	(1)	49	(48)
Sustaining	10	(11)	2	(4)	0	(0)	0	(0)	12	(15)
Total	664	(657)	157	(160)	27	(26)	7	(6)	(855)	(849)

Membership Committee

The distribution of memberships for 2005 is shown in the table on previous page, with the comparable numbers for 2004 in parentheses. These statistics do not include the 23 affiliate organizations which receive complimentary copies of *Trail & Landscape*.

During 2005, the club lost a long time member with the death of Eileen Evans, who joined the club in 1974 and served on Council as Corresponding Secretary from 1990 to 1996. Eileen was an important organizer and contributor to the social part of the monthly meetings at the Canadian Museum of Nature and the annual Soirée for many years.

DAVE SMYTHE
Chair, Membership Committee

Publications Committee

The Publications Committee met three times in 2005.

Only two issues of *The Canadian Field-Naturalist* were published in 2005: Volume 118, numbers two and three. These two issues contained a total of 336 pages; 32 articles; 15 notes; 41 book reviews; 71 new titles; 1 commemorative tribute; 14 pages of News and Comments; and 2 pages of miscellany. The journal fell further behind schedule largely because of some problems with the (relatively new) printer. These problems seem to have been solved, and the next four issues were near to being ready for production. The possibility of eventual electronic publication was considered at some length, and is continuing. For the present, the Abstracts of *CFN* papers will be posted on the OFNC website (to accompany the Tables of Contents which have been appearing there for some time). None of the Manning funds were drawn upon in 2005.

Volume 39 of *Trail & Landscape* was published in four issues containing a total of 200 pages having the usual excellent mix of articles.

RONALD E. BEDFORD
Chair, Publications Committee

Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the balance sheet of THE OTTAWA FIELD NATURALISTS' CLUB as at 30 September 2005, the statement of changes in net assets, and the statements of operations. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with Canadian generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, the Ottawa Field-Naturalists' Club derives some of its revenue from donations and fund raising activities. These revenues are not readily susceptible to complete audit verification, and accordingly, my verification was limited to accounting for the amounts reflected in the records of the organization.

In my opinion, except for the effect of the adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenues referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the OFNC as at September 30, 2005, and the results of its operations and changes in net assets for the year then ended in accordance with Canadian generally accepted accounting principles.

JANET M. GEHR
Chartered Accountant

North Gower, Ontario
3 January 2006

The Ottawa Field-Naturalists' Club
Balance Sheet
September 30, 2005

	2005	2004
ASSETS		
CURRENT		
Cash (Note 1)	$ 27,819	$ 22,306
Investment certificates (Note 1)	29,401	29,175
Marketable securities (Note 2)	0	69,310
Accounts receivable	21,837	16,703
Prepaid expenses	1,000	1,000
	80,057	138,494
LAND – ALFRED BOG	3,348	3,348
MARKETABLE SECURITIES (Note 2)	338,834	191,740
	$ 422,239	$ 333,582
LIABILITIES AND FUND BALANCES		
CURRENT		
Accounts payable and accrued liabilities	$ 3,500	$ 2,000
Deferred revenue	12,049	11,714
	15,549	13,714
LIFE MEMBERSHIPS	14,079	13,607
NET ASSETS		
Unrestricted	147,823	62,667
Club reserve	100,000	100,000
Manning principal	100,000	100,000
Manning interest - OFNC	1,014	2,457
- CFN	20,490	15,805
Seedathon	810	1,281
Anne Hanes memorial	870	870
de Kiriline-Lawrence	16,619	18,429
Macoun Baillie Birdathon	1,180	1,052
Alfred Bog	3,805	3,700
	392,611	306,261
	$ 422,239	$ 333,582

The Ottawa Field-Naturalists' Club
Statement of Operations
for the Year Ended September 30, 2005

	2005	2004
REVENUE		
Memberships	$ 13,635	$ 13,969
Trail and Landscape	220	280
Interest	2,129	1,835
GST rebate	720	768
Other	622	373
	17,326	17,225
OPERATING EXPENSES		
Affiliation fees	652	670
Computer	1,846	1,294
Membership	1,363	1,168
Office Assistant	1,000	1,000
Telephone	1,733	1,640
Insurance	725	725
Audit	2,500	1,000
GST	1,755	1,214
Other	1,072	952
	12,646	9,663
CLUB ACTIVITY EXPENSES		
Awards	390	150
Birds	618	540
Education and Publicity	1,149	775
Excursions and Lectures	(1,805)	(508)
Macoun Field Club	466	606
Origins and History of OFNC	3,800	0
Soiree	228	270
Trail and Landscape	8,887	9,578
Fletcher Wildlife Garden (Note 4)	3,667	(1,734)
Other	0	84
	17,400	9,761
EXCESS EXPENSES OVER REVENUE	$ (12,720)	$ (2,199)

The Ottawa Field-Naturalists' Club
***The Canadian Field-Naturalist* — Statement of Operations**
for the Year Ended September 30, 2005

	2005	2004
REVENUE		
Memberships	$ 9,090	$ 9,313
Subscriptions	25,135	23,936
Reprints	6,578	5,574
Publication charges	23,270	23,685
Interest and exchange	9,824	8,290
GST rebate	2,503	3,889
Other	1,231	1,477
	77,631	76,164
EXPENSES		
Publishing	20,777	$ 46,385
Reprints	4,658	2,141
Circulation	8,532	6,442
Editing	2,394	3,587
Office Assistant	5,000	5,000
Honoraria	9,000	9,000
GST rebate	2,693	4,203
Other	191	65
	53,245	76,823
EXCESS EXPENSES OVER REVENUE	$ 24,386	$ (659)

The Ottawa Field-Naturalists' Club Notes to the Financial Statements
September 30, 2005

1. CASH

	2005	2004
Chequing	$ 16,144	$ 11,899
Savings	6,963	4,491
Nesbitt Burns	459	0
Fletcher Wildlife Garden	4,253	5,916
	$ 27,819	$ 22,306

Investment Certificates: 2005	Maturity Value	Maturity Date	Yield	Book Value
	$ 29,963	05/01/06	1.90%	$ 29,401

2. MARKETABLE SECURITIES 2005

Investment Certificates:	Maturity Value	Maturity Date	Yield	Book Value
Province of Newfoundland Coupon	$ 44,782	10/17/11	4.525%	$ 34,509
Province of Ontario Coupon	15,376	12/02/12	4.591%	11,106
Province of Manitoba Coupon	45,740	09/05/13	4.694%	31,909
Res CIBC Int BB6	70,827	10/31/14	4.144%	48,934
CMHC Global Debs	52,000	12/01/06	5.250%	53,539
Province of Ontario Bond	30,000	09/12/07	6.125%	31,187
Province of Newfoundland Bond	20,000	10/07/08	6.263%	20,538
Government of Canada Coupon	30,167	12/01/09	5.605%	23,534
Province of New Brunswick Bond	60,000	12/03/15	3.965%	62,510
Province of New Brunswick Bond	20,000	06/15/10	6.231%	21,068
				$338,834

3. CAPITAL ASSETS
Equipment at a cost of $16,748 is fully amortized.

4. FLETCHER WILDLIFE GARDEN

	2005	2004
REVENUE		
Human Resources and Skills Dev. Canada	$ 296	$ 2,892
TD Friends of the Environment Fund	0	2,888
Taverner Cup	96	418
Sales	3,463	3,376
GST	155	144
Donations	200	476
	4,210	10,194
EXPENSES		
Program	614	3,664
Backyard	2,142	2,176
Habitats	2,213	737
Interpretation centre	223	130
Administration	706	693
Publications	1,479	799
GST	388	261
Library	112	0
	7,877	8,460
	$(3,667)	$(1,734)

The Ottawa Field-Naturalists' Club Statement of Changes in Net Assets for the Year Ended September 30, 2005 (Note 5)

Net Assets	Beginning Balance	Excess Revenue CFN	Excess Expenses OFNC	Other Revenue	Other Expenses	Ending Balance
Unrestricted	$ 62,667	$ 24,386	$ (12,720)	$ 73,490 a	$ –	$ 147,823
Club reserve	100,000	–	–	–	–	100,000
Manning Principal	100,000	–	–	–	–	100,000
Manning - CFN	15,805	–	–	4,685	–	20,490
Manning - OFNC	2,457	–	–	1,172	(2,615 b)	1,014
Seedathon	1,281	–	–	807	(1,278 c)	810
Anne Hanes Memorial	870	–	–	–	–	870
de Kiriline-Lawrence	18,429	–	–	190	(2,000 d)	16,619
Macoun Baillie Birdathon	1,052	–	–	128	–	1,180
Alfred Bog	3,700	–	–	105	–	3,805
	$ 306,261	$ 24,386	$ (12,720)	$ 80,577	$ (5,893)	$ 392,611

5. STATEMENT OF CHANGES IN NET ASSETS
   a) Unrestricted other revenue includes a bequest of $62,250 from the Estate of Mildred Groh.
   b) Manning OFNC expenses: Innis Point Bird Observatory $2,000, Peregrine Falcon Watch $649.
   c) Seedathon Expenses: birdseed for club feeders, $809.
   d) Louise de Kiriline-Lawrence Expenses: Contribution to the defence of the Larose Forest at a hearing of the Ontario Municipal Board.

6. PUBLICATION LIABILITY

An annual membership fee or subscription entitles the member/subscriber to four issues of *The Canadian Field-Naturalist* based on a calander year. As the year end of the club is September 30, the Club incurs a liability for publishing the fourth issue of each publication.

At this time, however, the publication of *The Canadian Field-Naturalist* is running late. At September 30, 2005, the club owes members/subscribers of 2005 issue number 4 of 2004 and three issues of 2005. Although most of the work preparing these publications is done by volunteers, the club must pay for printing and mailing. Based upon recent costs, it is estimated that the club has a liability of $68,000 for the outstanding issues. This amount will be reduced by page charges to the authors in the amount of 40% of the printing costs.

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

September 30, 2005

1. Nature of Business

The organization is non-profit and incorporated under the laws of Ontario (1884). The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

The organization's financial instruments consist of cash, accounts receivable, marketable securities, and accounts payable. Unless otherwise noted, it is the management's opinion that the organization is not exposed to significant interest, currency, or credit risks arising from these financial instruments. The fair value of these instruments approximate their carrying values, unless otherwise noted.

3. Capital Assets

Capital assets in excess of $4,000 cost are recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

4. Statement of Changes in Financial Position

A statement of changes in financial position has not been provided as it would not provide additional meaningful information.

5. Foreign Currency

Transactions during the year in U.S. dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in U.S. dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30, 2005.

Gains or losses resulting therefrom are included in revenue or expenses.

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit by post **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** Manuscripts may also be submitted (one copy) by e-mail. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be printed on standard-size paper, **doublespaced throughout,** generous margins to allow for copy marking, and **each page numbered.** For Articles and Notes provide a bibliographic (citation) strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Photographic reproduction of line drawings, **no larger than a standard page,** are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the joumal.

Special Charges — Please take note

Authors **must share in the cost of publication** by paying $90 for each page, plus $30 for each illustration (any size up to a full page), and up to $90 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Editor.

Limited joumal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

Reprints

An order form for the purchase of reprints or pdf will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor
RR 3 North Augusta, Ontario K0G IR0 Canada

Book Reviews

ZOOLOGY: The Birder's Companion — Birds of the Dominican Republic and Haiti — Atlas of Bird Migration: Tracing the Great Journeys of the World's Birds — Handbook of the Birds of the World Volume II – Old World Flycatchers to Old World Warblers — Conservation of the Black-tailed Prairie Dog: Saving North America's Western Grasslands — Migrating Raptors of the Word: Their Ecology and Conservation — Land Snails of British Columbia — Songbird Journeys: Four Seasons in the Lives of Migrating Birds 379

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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

Patrons

Her Excellency The Right Honourable Michaëlle Jean
Governor General of Canada

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COVER: Incubating female Northern Hawk Owl *Surnia ulula*, remained seated on the nest for long periods of time, changing her position infrequently (nest number 1). Photo by Michael Patrikeev. 30 May 2001. See article pages 433–437.

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A Reevaluation of Sexual Dimorphism in the Postcranium of the Chasmosaurine Ceratopsid *Chasmosaurus belli* (Dinosauria: Ornithischia)

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Mallon, Jordan C., and Robert B. Holmes. 2006. A reevaluation of sexual dimorphism in the postcranium of the chasmosaurine ceratopsid *Chasmosaurus belli* (Dinosauria: Ornithischia). Canadian Field-Naturalist 120(4): 403–412.

The sexual dimorphism attributed to *Chasmosaurus belli* by Sternberg (1927) is revisited and reevaluated. A reexamination of the two specimens originally considered by Sternberg reveals that they are less complete than first suggested, with only a moderate amount of overlapping material between them. Only a few of the postcranial elements (humeri, sternal plates, and presacral vertebrae) show evidence of dimorphism, the significance of which is either doubtful or equivocal. Instead of representing sexual dimorphs, it is likely that the two specimens belong to separate species, *C. belli* and *C. russelli*, as evidenced by their distinct frill morphologies and by their stratigraphic segregation within the Dinosaur Park Formation of Alberta. These findings emphasize the need to remain sceptical about claims advocating sexual dimorphism in the fossil record in the absence of statistical significance or stratigraphic control.

Key Words: *Chasmosaurus*, Ceratopsia, Dinosaur Park Formation, sexual dimorphism, variation, Alberta.

Chasmosaurus are modest-sized (~1500 kg) ceratopsid dinosaurs known from the upper Campanian-aged beds (~75 Ma [million years ago]) of western North America. They are characterized by the possession of a premaxillary flange, recurved supraorbital horncores, and a broad parietosquamosal frill with a straplike posterior border (Forster et al. 1993). The type species, *Chasmosaurus belli* (Figure 1), was discovered in the middle strata of the Dinosaur Park Formation in Alberta and was originally named *Monoclonius belli* (Lambe 1902). Two additional species of *Chasmosaurus*, *C. russelli* and *C. irvinensis*, are currently recognized from elsewhere in the formation (Godfrey and Holmes 1995; Holmes et al. 2001; Ryan and Evans 2005). A further species, *C. mariscalensis*, has been described from the Aguja Formation in Texas (Lehman 1989), though it was recently given the new genus name *Agujaceratops* (Lucas et al. 2006) and may prove to be more closely related to *Pentaceratops* than to *Chasmosaurus* (Holmes et al. 2001; Diem and Archibald 2005).

Charles M. Sternberg (1927) reported on two specimens of *Chasmosaurus*, both identified as *C. belli*, on display at the National Museum of Canada (now the Canadian Museum of Nature) in Ottawa (Figure 2).

FIGURE 1. Life restoration of *Chasmosaurus belli*, based on CMN 2245. Illustration by JCM.

FIGURE 2. CMN 2280 (left) and CMN 2245 (right) on display at the National Museum of Canada (circa 1926). (Courtesy of the Canadian Museum of Nature).

As restored, the skeletons measured "approximately the same length but the bones of one… are much lighter in construction than those of the other" (Sternberg 1927: 67). According to Sternberg, the total length of the 'gracile' skeleton measured 4.93 m, while that of the "robust" skeleton measured 4.95 m. Unfortunately, their supports have since been disassembled and these original measurements cannot be verified. Sternberg attributed the difference in robustness between the two specimens to sexual dimorphism, stating, "it is thought that they represent male and female as it is common, among reptiles, for the female to be larger than the male" (Sternberg 1927: 67). This assumption has gone largely unchallenged in the literature (e.g., Lull 1933; Carpenter and Currie 1990; Dodson 1996), except for an implication by Godfrey and Holmes (1995) that the reported differences between the specimens do not reflect sexual dimorphism because they pertain to two separate species of *Chasmosaurus*.

The recognition of sexual dimorphism in a fossil species must begin with the establishment that the variation observed within that species does represent dimorphism. With only two reasonably complete skeletons of *Chasmosaurus belli* at his disposal, Sternberg could not have established this with certainty, and indeed, he neither quantified nor qualified the differences he observed between the specimens. It is also important to note that many of the bones were highly reconstructed with plaster and subsequently painted over so that the reconstructed portions cannot be easily identified. As chronicled by C. H. Sternberg (C. M. Sternberg's father) regarding the restoration of one of the skulls: "we had colored our plaster to resemble the fossil bone – no small task, by the way, as we had to learn to mix colors as well as do the work of a sculptor – with wax" (Sternberg 1917: 83). As such, the possibility remains that the difference in robustness between the two specimens might in part be attributable to the extensive restoration of certain elements. With these concerns in mind, we set out to identify and describe the variation noted between the skeletons, and conducted a reevaluation of Sternberg's original attribution of sexual dimorphism to *C. belli*.

Materials

The two *Chasmosaurus belli* skeletons (Figure 3) described by Sternberg (1927) reside in the collections of the Canadian Museum of Nature in Aylmer, Quebec. The "gracile" specimen was designated CMN 2245; the "robust," CMN 2280. CMN 2245 was collected from quarry Q037, and CMN 2280 from Q010, of the Dinosaur Park Formation (upper Campanian, ~75 Ma) in Dinosaur Provincial Park, Alberta (originally referred to by Sternberg [1927: 67] as the "Belly River series").

CMN 2245 (Figure 3A) is represented by the posterior half of a skull and mandibles (missing only the predentary), complete presacral series, synsacrum complete to the sixth sacral vertebra, twenty-four caudal vertebrae, most cervical and thoracic ribs, pectoral gir-

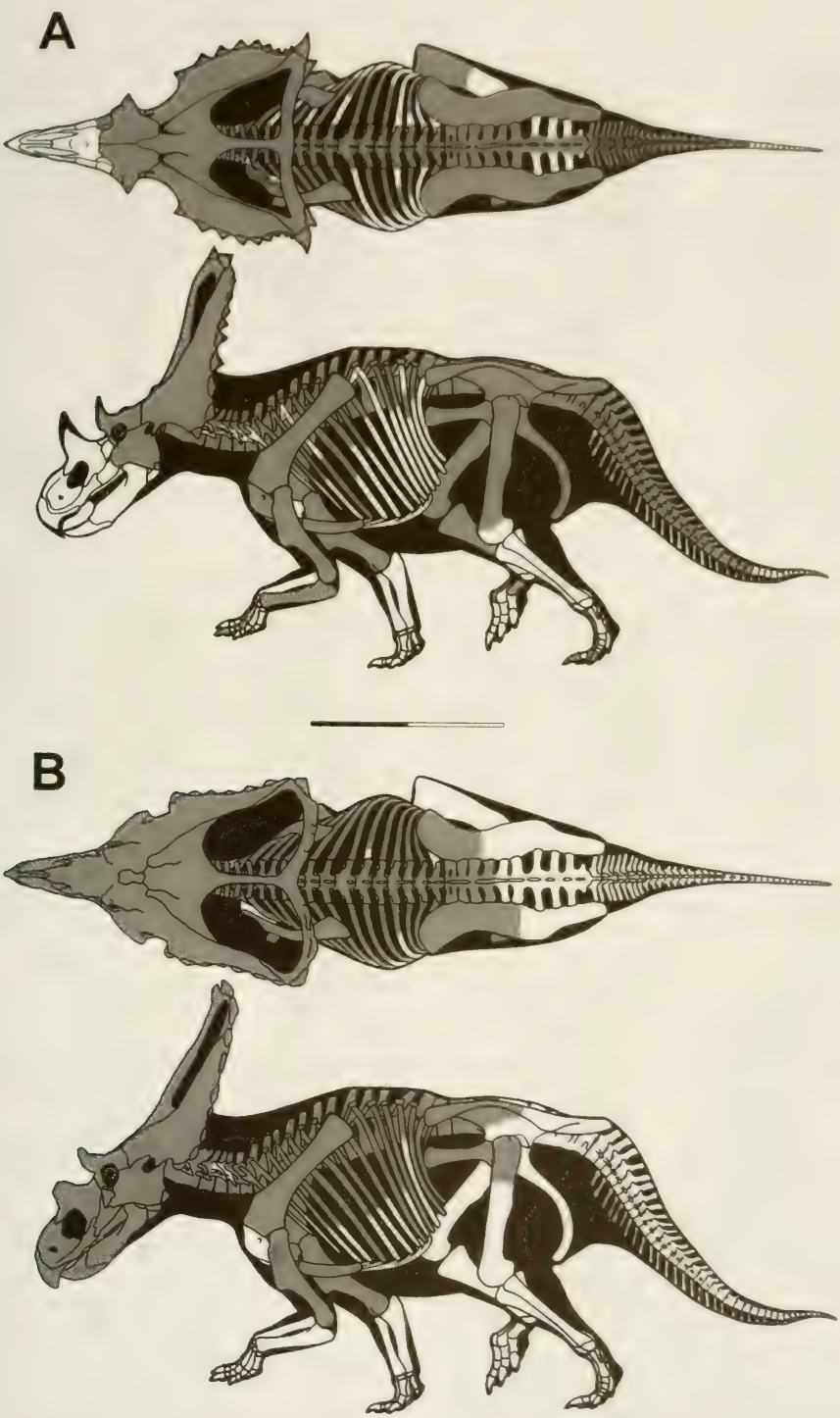

FIGURE 3. Material (in grey) attributed to (**A**) CMN 2245 and (**B**) CMN 2280. Scale bar = 1 m. Modified from original skeletal drawing by Gregory S. Paul. Used with permission.

dle (missing only the right coracoid), both humeri, left ulna, pelvic girdle, both femora, right tibia and fibula, and several carpal and tarsal elements.

CMN 2280 (Figure 3B) consists of a complete skull and mandibles, complete presacral series, synsacrum complete to the fourth sacral vertebra, most cervical and thoracic ribs, pectoral girdle (missing only the left coracoid), both humeri, anterior halves of both ilia, both pubes, and the proximal third of the left femur. A return visit to the quarry has yielded more hindlimb material, but it was in poor condition and not collected (D. H. Tanke, personal communication).

Overlapping material between the two specimens therefore consists of the posterior region of the skull, presacral and anterior sacral vertebrae, most ribs, most of the pectoral girdle, humeri, anterior ilia, pubes, and left proximal femur.

Methods

In order to facilitate distinction between the original bone and plaster, the brown paint was removed from many of the bones using acetone and a stiff-bristled brush. In some instances, the removal of the paint was not warranted when it was obvious that the element of interest had been created entirely of plaster (in which case a simple tap with the knuckle would confirm suspicion). In this way, the original elements common to CMN 2245 and CMN 2280 could be identified.

Three hundred and fourteen measurements were then taken from the postcranium of each specimen to the nearest millimetre, primarily according to the standards of Chinnery (2001). For those elements not considered by Chinnery, such as those belonging to the axial skeleton, one of us (JCM) devised our own measurement parameters. Measurements below 300 mm were generally taken with Mitutoyo SD type dial callipers and measurements above 300 mm were taken either with simple outside callipers and measuring tape or with large (1.04 m) Helios brand Vernier callipers. Circumferences were measured using a tailor's measuring tape. Angles were measured from photographs using a protractor. All available postcranial elements were measured, but only those bones deemed reliably complete and shared between the two skeletons were considered in this study.

Comparative Osteology

Description of Overlapping Material

Although CMN 2245 and CMN 2280 exhibit modest variability in the dimensions of their overlapping elements (Figure 4), much of this appears to be due to the extensive restoration and occasional postmortem deformation of the skeletons. Despite this, the best preserved elements usually differ in size by only a few percent, which is insufficient to produce visually discernable dimorphism, and is probably within the realm of individual variation that might be expected in tetrapods (e.g., Rising and Somers 1989; Zaaf and Van Damme 2001; Kelly et al. 2006). The coracoids of CMN 2245 and CMN 2280 are noticeably different in shape, although the left and only coracoid preserved in the former specimen has been badly weathered and highly reconstructed as a result, and is therefore of limited use. Only a few bones differ considerably in several dimensions and are described below.

Humerus

The humerus (Figure 4A) of CMN 2280 is considerably more robust than that of CMN 2245 in most dimensions (Table 1), particularly those of the humeral head, deltopectoral crest, and midshaft circumference. Besides proportional differences in the humerus, the insertional scar for the *latissimus dorsi* muscle on the deltopectoral crest is much less pronounced in CMN 2245.

Sternal Plate

Although the sternal plate (Figure 4B) is quite similar in size and shape between the two specimens, the process at the posterior end of the element extends 42-55% further laterally in CMN 2280 than in CMN 2245.

Presacral Vertebrae

The presacral vertebrae (Figure 4C) of these specimens are uniform in most dimensions, with most apparent differences being attributable to the addition of plaster. However, in the region of the withers (anterior thoracics), the vertebrae of CMN 2280 average 21% taller (Figure 5A) and their neural spines 19° more erect (Figure 5B) than in CMN 2245. Similarly, the transverse processes of the cervical and anterior thoracic vertebrae of CMN 2280 average 17° more erect than in CMN 2245 (Figure 5C), although this is difficult to state with confidence given the artificial coalescence of the vertebrae and the incompleteness of many of their spinous processes in CMN 2245. It seems, too, that the transverse widths of the vertebral centra anterior to the sixth thoracic average 10% wider in CMN 2280 (Figure 5D).

Discussion

Preservation of CMN 2245 and CMN 2280

While CMN 2245 is the most complete skeleton of *Chasmosaurus* known to date, it is less complete and less well preserved than generally supposed (e.g., Dodson 1996: 107). Some of the elements touted by Sternberg (1927) as being complete, such as the femora and caudal vertebrae, are actually only partially represented by nondescript scraps of bone buried in plaster, causing confusion among later authors (e.g., Lull 1933). Many of the presacral vertebrae have also been artificially "fused" together with plaster, obscuring much of the detail. CMN 2280 is by far the better preserved of the two specimens, although it is less complete. Consequently, there is only a moderate amount of material shared between the two specimens, and additional overlapping material would be desirable to make a convincing case for dimorphism in *C. belli*.

FIGURE 4. Dimorphic overlapping material of (**A**) CMN 2245 and (**B**) CMN 2280. **i**, right and left humeri; **ii** right and left sternal plates; **iii** posterior thoracic vertebrae in anterior (left) and left lateral (right) views. Note that, because of the poor preservation of the overlapping vertebrae, the eighth thoracic vertebra is figured for CMN 2245 and the tenth thoracic vertebra is figured for CMN 2280. Scale bar = 10 cm.

A Reevaluation of Sexual Dimorphism in Chasmosaurus belli

Recognizing sexual dimorphism in a fossil species is rarely a straightforward task, especially given small sample sizes where subtle but statistically significant dimorphic characters are difficult to resolve (Padian et al. 2005). Chinnery (2001, 2004) attempted to discern morphological variation, including sexual dimorphism, in the appendicular skeleton of the Ceratopsia, but could find none. The dimorphism originally ascribed by Sternberg (1927) to CMN 2245 and CMN 2280 was presumably based on variation in the postcranial skele-

TABLE 1. Selected measurements (after Chinnery 2001) for left humeri of CMN 2245 and CMN 2280, showing the large differences between their dimensions. Dimensions in square brackets are estimated.

Measurement parameter	Dimensions (mm)		Disparity
	CMN 2245	CMN 2280	(%)
Width of deltopectoral crest	95	72	24
Deltopectoral crest length, from external tuberosity to distal end of deltoid muscle scar	225	272	17.3
Craniolateral view; proximal width	44	76	42
Head height	[56]	78	28
Head width	55	86	36
Circumference about midshaft*	216	275	21.5

* = parameter not used in Chinnery (2001).

ton, although distinct differences in frill morphology are also present (see below). These differences cannot be attributed to either allometry or ontogeny since both specimens are of comparable size. Nor are they likely due to geographic variation since both specimens were found less than nine kilometres from one another. Post-mortem distortion cannot account for the differences either, as most of the elements are relatively uncrushed.

A review of the overlapping material reveals that the most striking differences between CMN 2245 and CMN 2280 lie with the humerus. The disparity in the robustness of the humerus and in the size of the insertional scar for the *latissimus dorsi* muscle seems to follow the prediction made by Chapman et al. (1997) that sexual dimorphism in ceratopsians would be expressed in the limb bones. It is also reminiscent of the condition seen in the humerus of many pachypleurosaurid sauropterygians (e.g., Sander 1989; Cheng et al. 2004) and of the sauropod *Camarasaurus* (Ikejiri 2005). However, if these humeral characters alone separate male from female, then other specimens of *Chasmosaurus belli* should exhibit the same disparity in humeral robustness as well. A bivariate plot derived from a Principle Components Analysis by Chinnery (2001: 134) revealed that the humerus of CMN 2245 plots as an outlier from the other eleven *Chasmosaurus humeri* included in the study. As the deviation lies along the y-axis, the differences are likely due to shape rather than size. Thus, while the shape differences between the humeri of CMN 2245 and CMN 2280 are real, the highly asymmetrical sex ratio implied is very unlikely. The inability of Lehman (1990) to identify dimorphism in the humeri from a population of *C. mariscalensis*, and M. J. Ryan's (personal communication) failure to find the same in several populations of *Centrosaurus apertus*, further supports this position. Sternberg (1927) specifically states that "[t]here have been no bones of other individuals used in the mounts", so the differences cannot be ascribed to the incorporation of material from a smaller individual into the mount. It seems that the humeri of CMN 2245 are simply unusually small and gracile, although the reason for this is unclear.

The reasons for the disparity in the dimensions of the sternal plates and of the presacral vertebrae are likewise uncertain in the absence of more material. The apparently longer and more erect neural spines and transverse processes of CMN 2280 coincide with observations made by Tereshchenko (2001) of protoceratopsids, in which the spinous processes of the vertebrae were reputedly shown to be longer and more erect in males than in females. If this apparent dimorphism is sexual, however, it would imply the "robust" specimen (CMN 2280) was male rather than female (*contra* Sternberg 1927). This type of "normal" sexual dimorphism, in which the male is more massive than the female, is typical of most reptiles (Fitch 1981; Shine 1989; Brochu 2002).

Thus, undoubted differences (albeit fewer than originally implied by Sternberg) between the two specimens do exist. The marked difference in the size and shape of the humerus may simply be anomalous, unless we accept the unlikely hypothesis that of the twelve *Chasmosaurus humeri* measured by Chinnery (2001), eleven are of one sex and only one is of the other. Other differences, such as the specific shape of the sternal plates and the relative size and orientation of the spinous processes of the presacral vertebrae, might represent sexual dimorphism or intraspecific variation. It is also possible that all of the postcranial discrepancies noted here are functionally related, reflecting a developmental compensation of the extrinsic muscles of the forelimb in response to the atrophied humeri of CMN 2245. However, in the absence of a statistically significant sample, it is impossible to resolve this question. Whatever the significance of the variation, there seems little choice but to reject the hypothesis of sexual dimorphism.

Two-Species Hypothesis

It is possible that the few differences documented here within the postcranial skeletons of CMN 2245 and CMN 2280 may simply reflect that these two specimens represent separate species. In a review of the systematics of the genus *Chasmosaurus* (Godfrey and Holmes 1995), two species were diagnosed based on differences in parietosquamosal frill structure. *C. belli* was defined as possessing a "parietal frill with nearly straight transverse posterior bars, each bearing one large

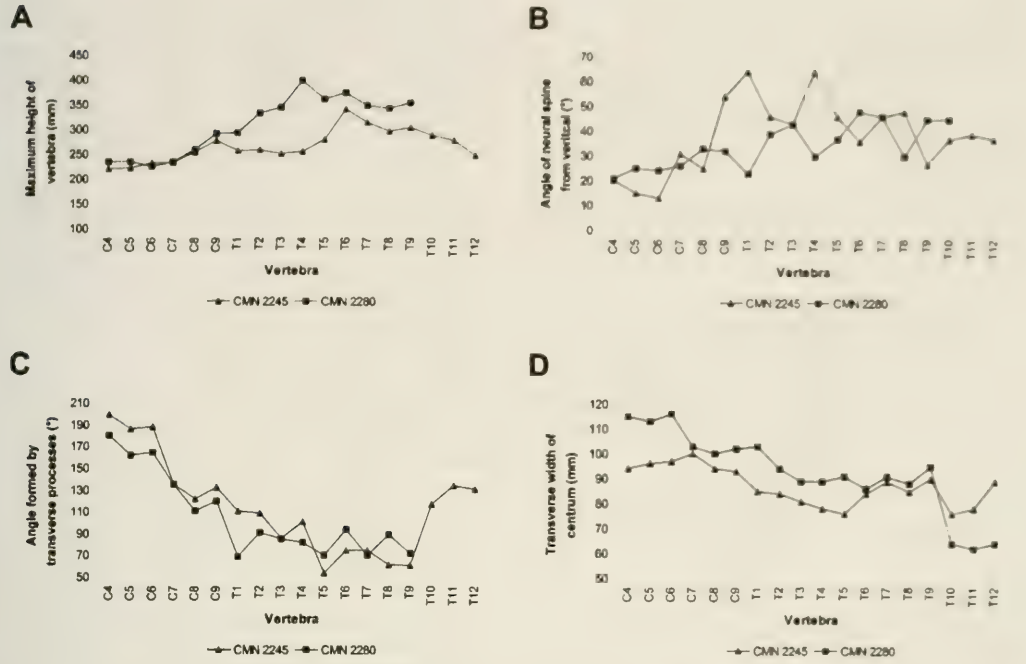

FIGURE 5. Graphical depictions of vertebral disparity between CMN 2245 and CMN 2280. **A**, Differences between maximum heights of vertebrae. The anterior thoracic vertebrae of CMN 2280 are consistently taller than those of CMN 2245. **B**, Differences between angles of neural spines. In the anterior thoracic region, the neural spines of CMN 2245 are angled further posteriorly than in CMN 2280. **C**, Differences between angles formed by transverse processes. The transverse processes of the cervical and anterior thoracic vertebrae of CMN 2280 are more erect than those of CMN 2245. **D**, Differences between transverse widths of centra. The cervical and anterior thoracic centra of CMN 2280 are consistently wider transversely than those of CMN 2245. Abbreviations: C, cervical vertebra; T, thoracic vertebra.

triangular epoccipital on its posterolateral corner; other parietal epoccipitals variable in number and degree of coossification with the parietal, but always much smaller. The lateral bar of the parietal completely encloses the parietal fenestra." *C. russelli* was characterized as having a frill in which the posterior margin is "broadly arched on either side of [the] median emargination. Each side bears three low triangular, roughly equal-sized epoccipitals. The lateral ramus of the parietal is reduced and does not completely encircle the fenestra in all but one specimen, permitting the squamosal to form a part of its lateral border." Under these amended diagnoses, CMN 2245 was retained within the hypodigm of *C. belli*, but CMN 2280 was reassigned to *C. russelli*. This distinction was challenged by Lehman (1998), who argued that the discrete characters used to distinguish *C. belli* from *C. russelli* actually represent end-members of a gradational spectrum of frill morphologies. In support of his argument, Lehman (1998: figure 9) figured seven skulls attributed to *C. belli* and *C. russelli*, illustrating the range of frill morphologies he observed. However, the lateral parietal bars of AMNH 5402 used by Lehman are not illustrated as being complete as they are in the original specimen, which creates the false impression that the frills exhibit graded variation. Correcting for this splits the series into two discrete groupings of frill morphologies (Figure 6), the contents of which agree with the original hypodigms of Godfrey and Holmes (1995).

Further support for the distinction between *C. belli* and *C. russelli* stems from their stratigraphic segregation within the Dinosaur Park Formation (Figure 7). This observation was made previously by Godfrey and Holmes (1995) and Holmes et al. (2001), and more recent quarry data support this claim, with *C. russelli* confined to the lower part of the formation and *C. belli* located much higher in the section (Ryan and Evans 2005). These independent lines of evidence strongly suggest that the variation between CMN 2245 and CMN 2280 is interspecific in nature, negating Sternberg's case for sexual dimorphism. Stratigraphic separation has also been noted recently among the supposedly sexually dimorphic lambeosaurine hadrosaurids of the Dinosaur Park Formation (Evans et al. 2006),

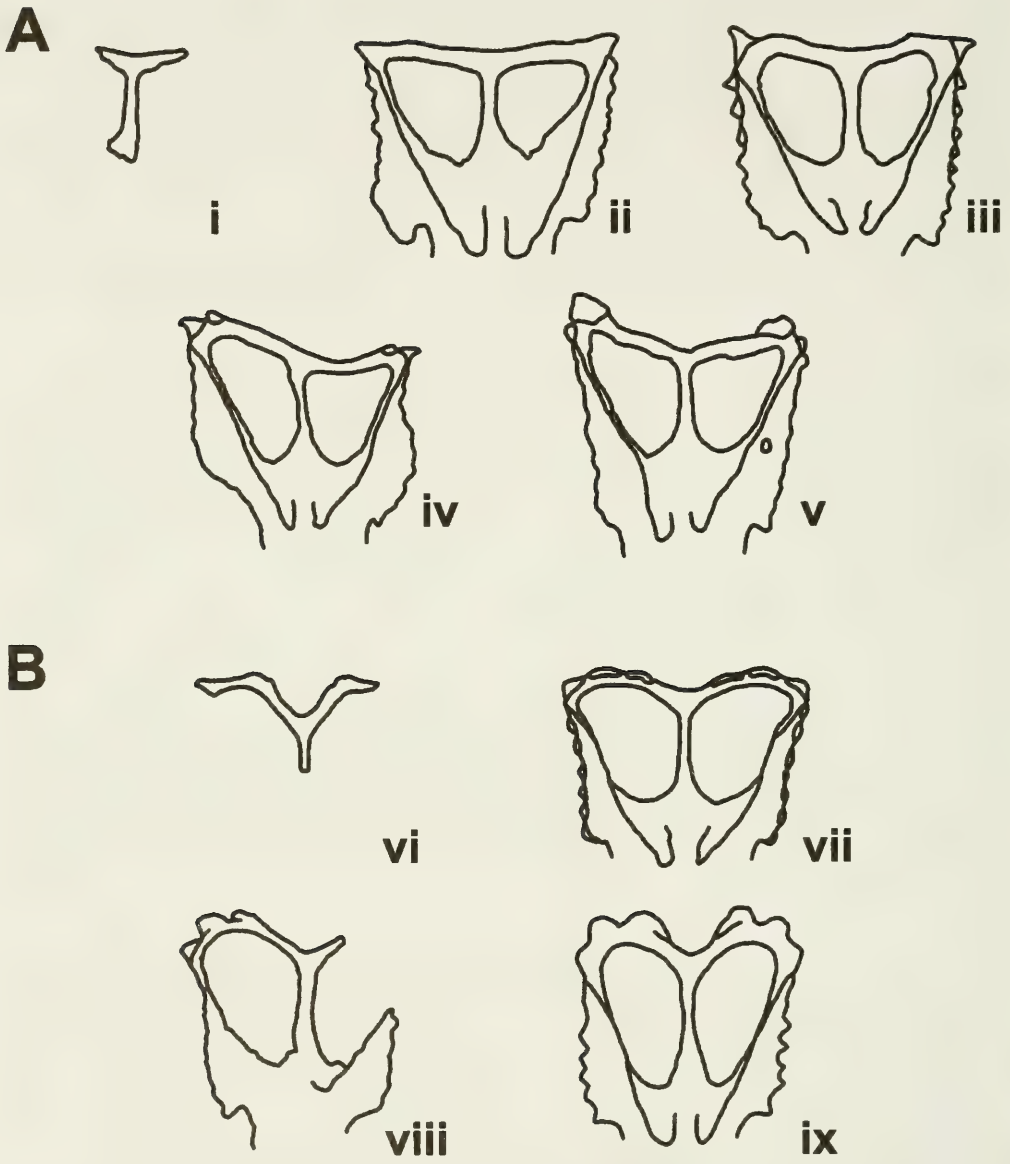

FIGURE 6. Parietosquamosal frills of (**A**) *Chasmosaurus belli* and (**B**) *C. russelli* in dorsal view. **i**, CMN 491 (holotype of *C. belli*); **ii**, YPM 2016; **iii**, CMN 2245 (paratype of *C. belli*); **iv**, AMNH 5402; **v**, ROM 843; **vi**, CMN 8803 (paratype of *C. russelli*); **vii**, CMN 2280; **viii**, RTMP 83.25.1; **ix**, AMNH 5656. Frills not to scale.

suggesting a need for more critical consideration of sexual dimorphism in the fossil record.

Conclusion

After a careful review of CMN 2245 and CMN 2280, it seems that the postcranium of neither specimen is quite as complete or as well preserved as originally described by Sternberg (1927). Consequently, the case for dimorphism (sexual or otherwise) is weaker than previously thought. Most of the variation exhibited by the shared elements is attributable either to poor reconstruction, postmortem distortion, or individual variation. Exceptional cases involve the humeri, sternal plates, and presacral vertebrae.

While the disparity in the shape of the humerus is indeed genuine, the same dimorphism is not seen in other specimens of *Chasmosaurus*, so this feature is likely anomalous rather than dimorphic. The sternal plates of CMN 2245 and CMN 2280 differ in the lengths of their posterolateral processes, and the presacral ver-

tebrae differ in the lengths and orientations of their spinous processes. However, analysis of additional *Chasmosaurus* material – preferably derived from some yet undiscovered monodominant bonebed (Eberth and Getty 2005) – would be necessary to determine the significance of this variation with regards to sexual dimorphism. The results presented here are therefore only preliminary, pending further investigation of individual variation in the ceratopsian postcranial skeleton.

Finally, previous detailed reviews of the frill morphology of either specimen seem to suggest that CMN 2245 and CMN 2280 may, in fact, belong to separate species (*C. belli* and *C. russelli*, respectively), as first put forth by Godfrey and Holmes (1995). This view is further supported by the stratigraphic segregation of the two specimens within the Dinosaur Park Formation of Alberta. Whether the postcranial differences identified here represent interspecific distinctions remains to be demonstrated. Therefore, although there do seem to be a few legitimate differences between the two specimens, the weight of the evidence so far accumulated does not support sexual dimorphism as Sternberg (1927) first suggested it, and there remains little choice but to reject this hypothesis. In the future, sexual dimorphism should be attributed to fossil species only when statistical significance and stratigraphic control have been demonstrated. Claims made in the absence of such evidence should be regarded with scepticism.

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We would like to thank Gilles Danis, Margaret Feuerstack and Kieran Shepherd for offering access to specimens in their care. Philip Currie and Hans Larsson provided valuable resources and discussion. Andrew Farke, Michael Ryan, and two anonymous reviewers provided constructive criticism on earlier versions of this manuscript. This research stems from a B.Sc. Honours thesis written by JCM under the supervision of RH.

Institutional Abbreviations

AMNH, American Museum of Natural History, New York, New York; CMN, Canadian Museum of Nature, Ottawa, Ontario; RTMP, Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta; YPM, Yale Peabody Museum, New Haven, Connecticut.

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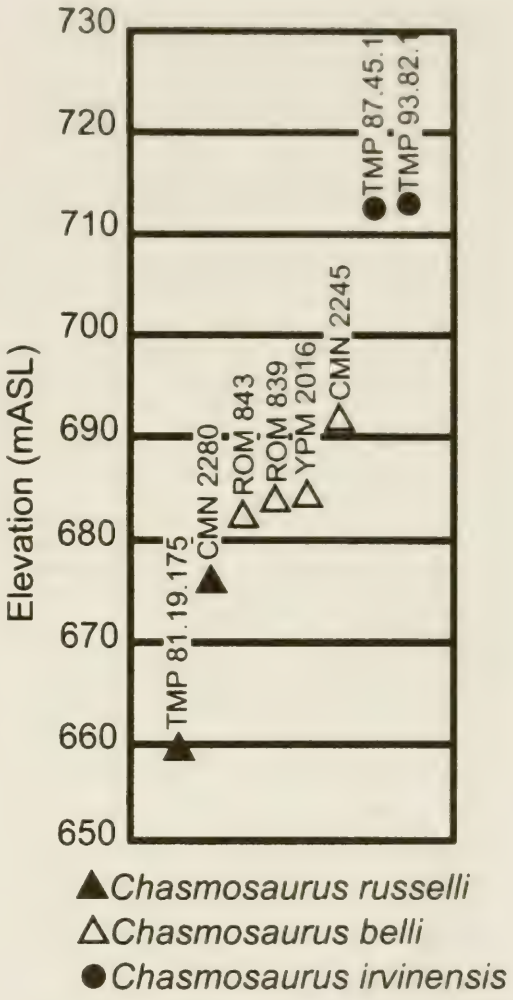

FIGURE 7. Stratigraphic distribution of *Chasmosaurus* from the Dinosaur Park Formation of Alberta (modified from Ryan 2003). Data from Currie and Koppelhus (2005*).

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Use of Saltmarsh by Dragonflies (Odonata) in the Baie des Chaleurs Region of Quebec and New Brunswick in Late Summer and Autumn

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During late summer and autumn, in the Baie des Chaleurs region of Quebec, 18 species of adult dragonflies were recorded during one or more visits of at least 2 hours each to 14 saltmarshes. Three species, *Aeshna canadensis*, *Sympetrum danae* and *S. internum*, were present in more than half of the sites. The most abundant species was *S. internum* with over 100 seen at some locations. Adults of several species, including *Aeshna canadensis*, *A. umbrosa*, *Enallagma civile*, *E. hageni*, *Ischnura verticalis*, *Lestes disjunctus*, *Libellula quadrimaculata*, *Sympetrum danae*, *S. internum* and *S. obtrusum*, occurred in relatively high frequencies in both Baie des Chaleurs saltmarshes and in those elsewhere in Acadia. Within Baie des Chaleurs observations of emergence and/or presence of larvae, as well as regional abundance, were recorded for *Aeshna canadensis*, *A. umbrosa*, *Ischnura verticalis*, *Sympetrum costiferum*, *S. internum* and *S. vicinum*. Oviposition in saltmarsh pools was recorded for *Aeshna canadensis*, *Enallagma civile*, *E. hageni*, *Ischnura verticalis*, *Lestes congener* and *Sympetrum danae*. The saltmarsh dragonfly fauna of Baie des Chaleurs is significantly different from that of the rest of Acadia based on frequencies predicted from the latter region. To a large extent this difference is a result of significantly increased use of saltmarsh habitat by adults of six species including *Lestes congener*, *Sympetrum danae*, *Aeshna canadensis*, *Sympetrum costiferum*, *Lestes disjunctus*, and *Sympetrum internum* (in order of decreasing significance) in Baie des Chaleurs in comparison with saltmarshes elsewhere in Acadia. Local amelioration of salty conditions in certain saltmarshes, superimposed on regional amelioration as a result of protection from storms and saltwater dilution in the Baie des Chaleurs estuary, may contribute to an environment where adaptation can occur or where already tolerant species can exist. Dragonflies use saltmarsh habitat on the northeast coast of North America more extensively than is currently documented.

Key Words: Odonata, dragonflies, saltmarsh, Baie des Chaleurs, Quebec, New Brunswick.

Dragonflies are generally not highlighted as a group of insects that inhabits saltmarshes (e.g. Cheng 1976). Foster and Treherne (1976) outline the difficulty of characterizing marine insects because many species wander in from adjacent habitats. They define marine insects as having a "habitual requirement for some part of the saltmarsh environment at some stage of their life cycle." They show Odonata species comprising 3% of saltmarsh insect fauna which is dominated by Diptera, Coleoptera and Hemiptera which collectively make up 75% of the species. Corbet (1999, page194) notes the only truly marine dragonfly is *Erythrodiplax berenice*, but that there is also a "heterogenous assemblage of Zygoptera and Anisoptera that occupy brackish waters, usually of relatively low salinity compared with seawater."

Dragonflies have been reported to prey on saltmarsh tabanid flies and mosquitos, both groups of aggressive biting insects that interfere with human activities. As a consequence, questions periodically arise as to the extent of use of saltmarsh by dragonflies. Very little information on this subject is available for the maritime region of eastern Canada. Hutchinson and Bélanger (1999, 2004) have reported on adults of *Sympetrum danae* and *Enallagma civile* (respectively) using saltmarsh in the Baie des Chaleurs region. These observations suggest that use of saltmarsh by dragonflies may be more extensive than suspected. Preliminary observations in the Baie des Chaleurs region of Quebec and New Brunswick supported this view and suggested the use of saltmarsh by widespread species of dragonflies.

The objective of the work reported here was to summarize information on the late summer and fall use of saltmarsh by dragonflies in this region and to provide a basis for further analysis of evolutionary and ecological aspects of occurrence.

Methods

The study area – Baie des Chaleurs

Baie des Chaleurs is bounded on the north by the Gaspé Peninsula and on the south by northern New Brunswick (Figure 1). Flowing into it at its far western end is the Restigouche River, famous for fishing of Atlantic Salmon, *Salmo salar*. The tides are approximately 2 m high in the western basin and seawater is encountered in the estuary where it expands at Campbellton, New Brunswick. More information on Baie des

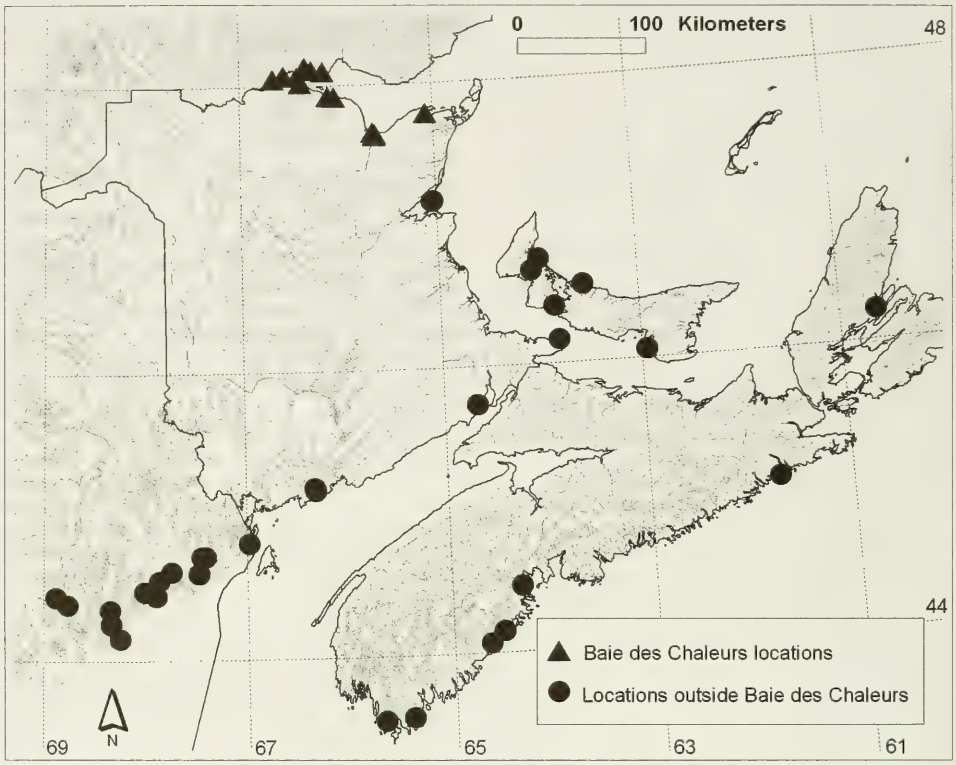

FIGURE 1. Region of Acadia showing saltmarshes visited in Baie des Chaleurs (triangles) and elsewhere (dots).

Chaleurs is available from Gauthier (2005), but there is apparently little information other than this recent reference (National Wetlands Working Group 1988).

Data gathering

Summarized below for the Baie des Chaleurs region are our late summer and fall observations of dragonflies in saltmarshes as well as some from the Atlantic Dragonfly Inventory Project (ADIP 2007*) for the same region. These observations cover the period from 22 July to 1 October over the past decade. The period of observation at any of these sites was at least 1-2 hours on any particular date. A list of observations at each site is followed by an annotated list of species and additional summary comments. In discussing the observations, the term "frequent" indicates a species seen often (e.g. at many sites) whereas "abundant" refers to a relatively large number of individuals at one or more sites.

All of the sites noted were dominated by plant species considered to be obligate halophytes, including two species of *Spartina* (*S. alterniflora* and *S. patens*), and *Ruppia maritima* was present in pools at most sites. The presence of these and other obligate halophytes indicates clearly that the sites were saltmarshes subject to periodic inflow of saltwater. Voucher specimens for the records of dragonflies for Baie des Chaleurs and elsewhere in Acadia are at the Canadian National Collection at the Agriculture and Agri-food (AAFC) Central Experimental Farm in Ottawa (Canadian National Collection CNC), and in the insect collections of the Nova Scotia Museum (NSMNH), the New Brunswick Museum (NFM) and the personal collection of P. M. Brunelle.

Comparisons

To explore differences between dragonfly occurrence in Baie des Chaleurs and elsewhere on the North Atlantic coast, the number of sites recorded for species of dragonflies in Baie des Chaleurs was compared with similar data (ADIP 2007*) for the rest of Acadia (Canadian Maritime Provinces and the state of Maine) outside of Baie des Chaleurs. Only records for the period from 22 July until the end of October are included in the comparison to represent late summer and autumn use of saltmarshes, and all records are for the past decade. Number of sites where a species was present was expressed as a percentage of total saltmarsh sites visited. The extent to which the Baie des Chaleurs dragonfly fauna is different was explored us-

FIGURE 2. Brackish pool in saltmarsh at St. Omer (site 4) where two females of *Sympetrum danae* were seen ovipositing in the foreground bed of floating algae and *Ruppia maritima*. The pool is surrounded by *Scirpus* spp., *Juncus gerardii* and *Spartina alterniflora*. Eight male *Sympetrum danae* patrolled the edge of this 25 m^2 pool, which is inundated by saltwater during high spring and fall tides.

ing a Chi-square test and percentage frequency elsewhere in Acadia to predict percentage frequency in Baie des Chaleurs. The test also allows the comparison of Chi-square values for individual species, but considering the sample size, the values are most useful to identify species contributing substantially to differences between Baie des Chaleurs and elsewhere, rather than to indicate a specific level of significance.

Results

Sites and species present

For each site, observation dates are given followed by species in alphabetical order and number of individuals seen in brackets. The total for each site and the size and nature of the area surveyed are also given. In cases where we are not the observers, the observers are listed at the end. A total of 18 species of Odonata was encountered in 14 saltmarshes in the Baie des Chaleurs in late summer and autumn.

(1) Bathurst (Queen Elizabeth and Youghall streets), New Brunswick (47.6648°N, 65.6328°W), 14 August 2005: *Aeshna canadensis* (25), *Enallagma hageni* (40), *Libellula quadrimaculata* (2), *Somatochlora elongata* (4), *Sympetrum costiferum* (5), *S. internum* (25), *S. vicinum* (4). Total: 7 species. Size: The site included a brackish ½ acre pool.

(2) 4 km E of Pointe-à-la-Croix, Quebec (48.0520°N, 66.6528°W), 15 August 2005: *Aeshna canadensis* (30), *Lestes congener* (4), *Lestes disjunctus* (2), *Sympetrum costiferum* (1), *S. danae* (9), *S. internum* (200), *S. obtrusum* (2). Total: 7 species. Size: 50 acres traversed, including creeks, pools and a river.

(3) Pointe-à-la-Garde, Quebec (48.0773°N, 66.5425°W), 15 August 2005: *Aeshna canadensis* (50), *Enallagma hageni* (43), *Lestes congener* (10), *L. disjunctus* (5), *Sympetrum costiferum* (1), *S. danae* (15), *S. internum* (150). Total: 7 species. Size: 10 acres traversed with many pools and creeks.

(4) Saint-Omer, Quebec (48.1087°N, 66.2514°W), 15 August 2005: *Aeshna canadensis* (18), *Lestes congener* (5), *L. disjunctus* (1), *Enallagma hageni* (1), *Sympetrum danae* (15). Total: 5 species. Size: 3 acres with pools beside creek (Figure 2).

(5) Charlo, New Brunswick (48.0182°N, 66.3666°W), 16 August 2005: *Aeshna canadensis* (1), *Lestes congener* (3), *Sympetrum danae* (1), *Sympetrum internum* (2). Total: 4 species. Size: ½ acre with one small pool.

(6) Nash Creek, New Brunswick (47.9229°N, 66.0840°W), 16 August 2005: *Aeshna canadensis* (6), *Sympetrum danae*

TABLE 1. Locations of saltmarshes visited in Baie des Chaleurs and elsewhere in Acadia over the past ten years within the period 22 July to 1 October. The order is increasing latitude from left to right and top to bottom.

Baie des Chaleurs			
47.6648, 65.6328	48.0520, 66.6528	48.0773, 66.5425	48.1087, 66.2514
48.0182, 66.3666	47.9229, 66.0840	47.9166, 66.0241	47.0657, 65.0750
48.1000, 66.1348	48.0500, 65.4833	48.1333, 66.3166	47.7846, 65.0841
47.64, 65.62	47.65, 65.61		
Acadia outside Baie des Chaleurs			
43.5694, 65.4139	43.5702, 65.3747	44.0667, 64.6417	44.1483, 64.5106
44.15, 68.25	44.2518, 68.3398	44.2535, 68.3406	44.35, 68.35
44.3889, 68.7667	44.4417, 68.8833	44.45, 67.9	44.4587, 64.3215
44.479, 68.013	44.5556, 67.8722	44.605, 67.48	44.6194, 67.7472
44.7194, 67.45	44.72, 67.41	44.8111, 66.9806	45.107, 61.7266
45.1699, 66.3135	45.19, 66.32	45.7321, 64.6765	46.06, 62.95
46.1635, 63.8258	46.2083, 60.6333	46.4, 63.86	46.5403, 63.56
46.6532, 64.0748	46.732, 63.9946	47.1667, 65.0493	47.1721, 65.0372

(1), *S. internum* (4), *S. obtrusum* (1). Total: 4 species. Size: 5 acres with pools and creeks.

(7) Jacquet River Marsh, New Brunswick (47.9166°N, 66.0241°W), 16 August 2005: *Aeshna canadensis* (30 adults 1 larva probably this species), *Aeshna umbrosa* (1 larva probably this species), *Lestes congener* (50), *L. disjunctus* (1), *Ischnura verticalis* (200 adults, 4 larvae), *Sympetrum danae* (1), *S. internum* (5). Total: 7 species. Size: traversed 10 acres with pools and creeks.

(8) North of Eel River, New Brunswick (48.0657°N, 66.4000°W), 16 August 2005: *Aeshna canadensis* (22), *A. interrupta* (3), *Enallagma civile* (26), *Enallagma hageni* (1), *E. ebrium* (1), *Ischnura verticalis* (100), *Lestes congener* (10), *L. disjunctus* (4), *L. forcipatus* (2), *Sympetrum internum* (70), *S. obtrusum* (40). Total: 11 species. Size: at least 50 acres traversed with numerous creeks and pools, all brackish, at least periodically.

(9) Carleton, Quebec (48.1000°N, 66.1348°W), 29 September–1 October 2004: *Aeshna umbrosa* (5+), *Enallagma civile* (3), *Sympetrum danae* (7), *S. internum* (1), *S. vicinum* (1); *S. costiferum* (1); 10 September 1999, *Enallagma civile* (2), *Sympetrum danae* (4); 4 September 1995, *Sympetrum danae* (3), *Sympetrum* sp. (1 reddish specimen). Total: 6 species. Size: pools within an area of 3 acres.

(10) Bonaventure, Quebec (48.0500°N, 65.4833°W), 3 September 1995: *Aeshna* sp. (2), *Pantala flavescens* (1), *Sympetrum costiferum* (1), *S. danae* (10). Total: 4 species. Size: 3 acres.

(11) Nouvelle (saltmarsh of the Nouvelle River Basin), Quebec (48.1333°N, 66.3166°W), 4 September 1995: *Lestes congener* (1), *Sympetrum danae* (1), *Sympetrum* sp. (1, reddish). Total 3 species.

(12) Caraquet Bay, New Brunswick (47.7846°N, 65.0841°W) saltmarsh, 12 August 2002: *Sympetrum danae* (3), *Sympetrum internum* (1), *Sympetrum obtrusum* (1). Observer: Dwayne L. Sabine. Total: 3 species.

(13) Daly Point Marsh, Bathurst Harbour, New Brunswick (47.64°N, 65.62°W), 12 August 1993: *Sympetrum danae* (1). Observer: Reginald P. Webster. 21 July 1999, *Libellula quadrimaculata* (2), *Aeshna canadensis* (2). Total 3 species.

(14) Carron Point Marsh, Bathurst Harbour, New Brunswick (47.65°N, 65.61°W), 22 July 1999: *Aeshna canadensis* (1), *Libellula quadrimaculata*, *Sympetrum danae* (2), *Sympetrum obtrusum* (1). Total: 4 species.

Annotated List of Species (alphabetical order)

Aeshna canadensis: at 10 sites and frequent at some, apparently uses saltmarsh regularly as an adult hunting on salty pools of the outer marshes which are influenced by tides regularly, as well as inner brackish pools; seen to oviposit in saltmarsh pools. A larva 20 mm long that was probably (but not definitely, due to difficulty of identifying young larvae) referable to this species was retrieved from a periodically brackish pool dominated by *Ruppia maritima* (site 7).

Aeshna interrupta lineata: only one at one site but of interest because this subspecies exists at low frequencies in the Atlantic provinces and is largely confined to the Gulf of St. Lawrence area. The specimen was referred to subspecies *lineata* on the basis of uninterrupted lateral stripes. This species is reported to tolerate saline waters (Dunkle 2000).

Aeshna umbrosa: only from two sites but five adults seen patrolling saltmarsh ponds; at the other site two young larvae probably referable to this species (21 and 23 mm long) were found in a brackish pool dominated by *Ruppia maritima* (site 7) – due to their small size, identification is tentative; mature larvae of this species were found in water-filled pockets within the storm splash zone of a sea cliff near Port-au-Saumon, Quebec (Hutchinson 1999); and D. Sabine (personal communication) found larvae in a small depression pool in a seaside boulder within the tidal splash zone on the Fundy shore of New Brunswick.

Enallagma civile: two sites; twenty-six captured (most released), many paired, were flying over a periodically brackish creek in saltmarsh with mostly *Ruppia maritima*, also *Zannichellia palustris*, *Potamogeton pectinatus*, lined by *Spartina alterniflora* (site 8). *Enallagma civile* was first reported from this region by Hutchinson and Bélanger (2004), and their report was from a saltmarsh habitat at Carleton (site 9), where they observed oviposition behaviour (but did not actually see eggs). Osborn (1906) reported a tolerance of brackish water.

Enallagma ebrium: only one at one site, so likely vagrant.

Enallagma hageni: At four sites and abundant at two; 40 seen and several ovipositing on *Ruppia maritima* around a brackish, ½ acre pool with dense beds of *Ruppia maritima* surrounded by *Spartina alterniflora*, *S. patens*, *S. pectinata*, and *Carex*

TABLE 2. Comparison of species of dragonflies recorded from Acadia outside of Baie des Chaleurs and Baie des Chaleurs based on number (left) and percentage (right) of total saltmarsh sites visited. Acadia includes the Maritime Provinces (Nova Scotia, New Brunswick and Prince Edward Island) of Canada and the state of Maine. Records from Acadia are from the ADIP database (2007). Records from Baie des Chaleurs are those reported here and are also in ADIP 2007. Only records for the period from 22 July until the end of October are included in the comparison to represent late summer and autumn use of saltmarshes. Chi-square values for each species based on comparison of frequency elsewhere in Acadia to predict frequency in Baie des Chaleurs are included to highlight species most different in their occurrence in these two regions in bold. Names are taken from Catling et al. (2005).

Species	Acadia n = 32		Chaleurs n = 14		Chi-square
Lestes congener Hagen, Spotted Spreadwing	1	3.1	7	50.0	**352.8872**
Lestes disjunctus Sélys, Northern Spreadwing	5	15.6	5	35.7	**21.4439**
Lestes forcipatus Rambur, Sweetflag Spreadwing	1	3.1	1	7.1	2.6130
Lestes inaequalis Walsh, Elegant Spreadwing	1	3.1	–	–	1.5500
Lestes rectangularis Say, Slender Spreadwing	4	12.5	–	–	**10.0160**
Lestes unguiculatus Hagen, Lyre-tipped Spreadwing	2	6.2	–	–	4.1333
Enallagma aspersum (Hagen), Azure Bluet	1	3.1	–	–	1.5500
Enallagma civile (Hagen), Familiar Bluet	8	25.0	2	14.3	4.1125
Enallagma durum (Hagen), Big Bluet	1	3.1	–	–	1.5500
Enallagma ebrium (Hagen), Marsh Bluet	2	6.2	1	7.1	0.0920
Enallagma hageni (Walsh), Hagen's Bluet	10	31.2	4	28.6	0.2125
Ischnura verticalis (Say), Eastern Forktail	6	18.7	2	14.3	0.9084
Aeshna canadensis Walker, Canada Darner	7	21.8	10	71.4	**98.2049**
Aeshna constricta Say, Lance-tipped Darner	3	9.3	–	–	6.9759
Aeshna eremita Scudder, Lake Darner	2	6.3	–	–	4.2223
Aeshna interrupta Walker, Variable Darner	5	15.6	1	7.1	3.8409
Aeshna umbrosa umbrosa Walker 1908, Shadow Darner	4	12.5	2	14.3	0.1963
Anax junius (Drury), Common Green Darner	1	3.1	–	–	1.5500
Dorocordulia lepida (Hagen in Sélys), Petite Emerald	2	6.2	–	–	4.1333
Somatochlora elongata (Scudder), Ski-tipped Emerald	3	9.3	1	7.1	0.3815
Somatochlora kennedyi Walker, Kennedy's Emerald	1	3.1	–	–	1.5500
Celithemis elisa (Hagen), Calico Pennant	1	3.1	–	–	1.5500
Erythrodiplax berenice (Drury), Seaside Dragonlet	8	25.0	–	–	**22.2420**
Leucorrhinia frigida Hagen, Frosted Whiteface	1	3.1	–	–	1.5500
Libellula luctuosa Burmeister, Widow Skimmer	1	3.1	–	–	1.5500
Libellula pulchella Drury, Twelve-spotted Skimmer	2	6.2	–	–	4.1333
Libellula quadrimaculata Linnaeus, Four-spotted Skimmer	9	28.1	3	21.4	1.4495
Pantala flavescens (Fabricius), Wandering Glider	3	9.3	1	7.1	0.3815
Plathemis lydia (Drury), Common Whitetail	2	6.2	–	–	4.1333
Sympetrum costiferum (Hagen), Saffron-winged Meadowhawk	3	9.3	5	35.7	**55.8876**
Sympetrum danae (Sulzer), Black Meadowhawk	5	15.6	12	85.7	**261.2840**
Sympetrum internum Montgomery, Cherry-faced Meadowhawk	12	37.5	9	64.3	**17.4604**
Sympetrum obtrusum (Hagen), White-faced Meadowhawk	9	28.1	5	35.7	1.8149
Sympetrum semicinctum (Say), Band-winged Meadowhawk	5	15.6	–	–	**13.0139**
Sympetrum vicinum (Hagen), Autumn Meadowhawk	2	6.2	–	–	4.1333

paleacea, flooded by high tides in fall according to local residents (site 1); 43 around pools and creeks with *Ruppia maritima*, *Zannichellia palustris*, *Potamogeton pectinatus* and *Enteromorpha* sp. (site 3).

Ischnura verticalis: abundant at each of two locations; more than 200 seen around pools with *Potamogeton pectinatus* and *Ruppia maritima* with *Spartina pectinata* fringe, some ovipositing, and at the the same location four larvae 17-21 mm long referable to this species were collected from the pools (site 7); more than 100 were seen around spring-fed pools surrounded by *Spartina pectinata*, *Spartina alterniflora, Spartina patens* and species of *Scirpus* (site 8). In both cases the pools were fed by freshwater springs but were definitely subject to saltwater during high tides.

Lestes congener: at seven sites and at least 82 individuals overall; given the number of sites and the number of individuals this species may be a resident of saltmarsh; several pairs seen ovipositing on *Juncus balticus* and *Juncus gerardii* around brackish pools with *Potamogeton pectinatus* and *Ruppia maritima* (site 7).

Lestes disjunctus: at five sites; but not as abundant as *L. congener*.

Lestes forcipatus: only one at one location.

Libellula quadrimaculata: at three sites; adults patrolled a brackish pool at site 1; said to tolerate saline waters (Dunkle 2000).

Pantala flavescens: only one at one location and probably a migrant.

Somatochlora elongata: only found at one location, but four seen over pool with *Ruppia maritima* surrounded by *Spartina alterniflora, S. patens, S. pectinata*, and *Carex paleacea*, flood-

ed by high tides in fall according to local residents (site 1). This species has also been reported from four other saltmarshes in Acadia (Table 2).

Sympetrum danae: at 12 sites, and abundant on the north side of the bay, patrolling saltmarsh pools very much like *Erythrodiplax berenice* does in saltmarshes further south on the Atlantic coast. Two females were seen ovipositing in a pool 25 m^2 with a thick bed of *Ruppia maritima* surrounded by *Scirpus* spp., *Juncus gerardii* and *Spartina alterniflora* (site 4, Figure 2). The pool was said by local people to be flooded by high tides in spring and fall. Ovipositing behaviour was also observed in saltmarsh ponds at Carleton but eggs were not actually seen. The species appears to be less frequent in the saltmarshes on the south side of the bay. Hutchinson and Bélanger (2004) have previously drawn attention to the utilization of saltmarsh by adults of this species and suggested the possibility that larvae may mature in brackish pools. High salinity of spring and fall high tides may be avoided by the resistant egg stage that overwinters. Larval development may be relatively rapid (Corbet 1999) and allow use of saltmarsh pools during periods of minimal tidal impact. Although the larval habitat of this species is widely reported in both Europe and North America as oligotrophic pools and small lakes on bogs and heathlands, it also inhabits very alkaline fens in eastern and northern Canada. Consequently saltmarsh pools would not be so remarkable a habitat. Interestingly in Ireland, males are said to be non-territorial (Nelson and Thompson 2000*), contrary to some of our observations on saltmarsh pools. In some places within its holarctic range, *S. danae* is reported to migrate (e.g. Corbet 1999, page 420). Ability to utilize brackish habitats may be beneficial to migrants over water in the maritime regions where landfall may have only brackish habitat.

Sympetrum internum: at nine sites and abundant at some. One emerging from a pool surrounded by *Spartina pectinata* in upper marsh (site 2) and tenerals in several sites; uses saltmarsh extensively as an adult and the upper marsh at least to some extent as larval habitat.

Sympetrum costiferum: at five sites; two emerging from brackish ½ acre pool with dense beds of *Ruppia maritima* surrounded by *Spartina alterniflora*, *S. patens*, *S. pectinata* and *Carex paleacea*, flooded by high tides in fall according to local residents (site 1); one emerging from sandy bottom creek with *Ruppia maritima* and *Enteromorpha* sp. (site 3). Apparently uses saltmarsh habitats for development but in low numbers, possibly due to limited amount of sandy larval habitat in most marshes. According to Walker and Corbet (1975), *S. costiferum* appears to be more tolerant of saline waters than other species of *Sympetrum*, but they are not clearly referring to sodium salts. Dunkle (2000) also refers to tolerance of saline waters.

Sympetrum obtrusum: at five sites but no strong evidence of use of saltmarsh as larval habitat by this widespread and generally abundant species.

Sympetrum vicinum: at two locations but at one of these two were emerging from brackish ½ acre pool with dense beds of *Ruppia maritima* surrounded by *Spartina alterniflora*, *S. patens* and *S. pectinata*, and *Carex paleacea*, flooded by high tides in fall according to local residents (site 1).

Discussion

Comparison with saltmarshes elsewhere in Acadia

A total of 35 species has been recorded from saltmarshes in Acadia (Table 2). Several occurred in relatively high frequencies in both Baie des Chaleurs saltmarshes and saltmarshes elsewhere in Acadia suggesting some degree of salinity tolerance. Included in this category are *Aeshna canadensis, A. umbrosa, Enallagma civile, E. hageni, Ischnura verticalis, Lestes disjunctus, Libellula quadrimaculata, Sympetrum danae, S. internum* and *S. obtrusum*.

With a Chi-square value of 912.707, the saltmarsh dragonfly fauna of Baie des Chaleurs is significantly (well below the 0.005 level) different from that of the rest of Acadia based on frequencies predicted from the latter region. Based on Chi-square values exceeding 10.0 (significance below the 0.005 level), Baie des Chaleurs saltmarshes differed from sites elsewhere in having significantly more sites for six generally widespread species that occur throughout Acadia (Table 2, Donnelly 2004a, b, c) including *Lestes congener, Sympetrum danae, Aeshna canadensis, Sympetrum costiferum, Lestes disjunctus*, and *Sympetrum internum* (in order of decreasing significance). Three species were significantly less frequent in Baie des Chaleurs including *Erythrodiplax berenice, Sympetrum semicinctum*, and *Lestes rectangularis* all of which do not extend as far north as Baie des Chaleurs (Donnelly 2004b, c). *Erythrodiplax berenice* for example does not occur north of 45°N, whereas Baie des Chaleurs is situated at 48°N.

General Observations

With 35 species of adult dragonflies recorded in saltmarshes in Acadia and 18 in Baie des Chaleurs, and in both cases, approximately half of them occurring in more than 15% of sites, substantial use by dragonflies is suggested. This is further supported by records of emergence, presence of larvae, ovipositing behaviour and relatively large numbers of individuals.

In a number of saltmarsh habitats further south on the coast of New England, the only abundant dragonfly species that we have observed using the saltmarsh habitat in late summer is the saltmarsh specialist, *Erythrodiplax berenice*. It is often present in large numbers (to 30 per acre), the males patrolling pools, the females along the marsh edges but pairs frequent over the marsh in early to mid-morning. Other Odonatists have also noted that in many saltmarshes the only dragonfly present is *E. berenice* (D. Paulson, personal communication). Other species fly over the marshes including the migratory *Anax junius*, *Tramea* spp., and *Pantala* spp. All of these may hunt over the marsh but seem much more often to hunt and congregate in open shrubby areas around the marsh edge. We have seen species of *Enallagma, Lestes* and *Sympetrum* only occasionally in these more southern saltmarshes. There may be a trend toward more extensive use of saltmarsh by dragonflies in a northerly direction. Possibly saltmarshes further south are less utilized by widespread dragonfly species because salt may be more concentrated in pools of upper marsh due to higher evaporation.

Baie des Chaleurs

The fact that Baie des Chaleurs saltmarshes differed from sites elsewhere in Acadia in having very significantly more sites for six generally widespread species, including *Lestes congener, Sympetrum danae, Aeshna canadensis, Sympetrum costiferum, Lestes disjunctus*, and *Sympetrum internum* (in order of decreasing significance), suggests either that there has been some adaptation to saltmarsh conditions by these wide-ranging species in this region, or that saltmarshes in this region are more readily colonized as a result of unique characteristics, or both. Baie des Chaleurs is home to an endemic and endangered saltmarsh butterfly, the Maritime Ringlet (*Coenonypha tullia nipisiquit,* McDunnough 1939). Recent studies have suggested that this butterfly has evolved physiological adaptation to saline wetland conditions including tolerance of tidewater submergence for up to 24 hours (Webster 1998; Sei 2004). The endemic but somewhat more widespread Maritime Copper Butterfly (*Lycaena dospassosi* McDunnough) is also confined to the saltmarshes of northern New Brunswick and Gaspé (Thomas 1980).

Unique charaterisitics of Baie des Chaleurs saltmarshes may be widespread or local, or both. Parts of saltmarsh are prohibitively salty for non-adapted species only during high tides in the spring and fall, and even then saltwater may be somewhat diluted due to the estuary effect. There are distinctive east and west basins and in the west basin, where most of our observations were made and where the Maritime Ringlet occurs, the tides are higher and salt concentrations lower than in the east basin (Gauthier 2005). It has been suggested that saltmarshes can be divided into two kinds, estuarine such as Baie des Chaleurs, and coastal (National Wetlands Working Group 1988). Although the difference between the two types is not perfectly clear, conditions of inundation and salt concentrations in coastal saltmarsh would be more severe.

Saltmarshes have periodic inundation in common, but the timing and duration may vary as well as the salt concentrations. Furthermore, occasional lack of ice development in the bay may result in severe impact of high tide associated with winter storms on some saltmarshes, while others may be protected by barrier beaches (Webster 1994*, 1998). Local amelioration of salty conditions in certain saltmarshes, superimposed on regional amelioration, may provide an environment where tolerant species can exist and adaptation can occur.

Tolerance of salt

Although the places where dragonflies were recorded in Baie des Chaleurs saltmarshes may not have been consistently high in salt concentration, they were definitely brackish, were part of a tidal salt marsh subject to periodic inundation with salt water and subject to salt to the extent of excluding non-halophytic flora. Species of dragonflies differ in their ability to cope with salt (Cannings and Cannings 1987). Of the 18 species found in Baie des Chaleurs, *Aeshna interrupta, Libellula quadrimaculata, Sympetrum danae*, and *S. costiferum* are reported by Dunkle (2000) to tolerate saline water. However, Walker (1953, 1958), Walker and Corbet (1975), Pilon and Lagacé (1998) do not report any of the species listed here as occurring in saltmarsh. Observations in Baie des Chaleurs suggest that dragonflies occupy saltmarshes to a greater extent than is currently documented. Ecological and evolutionary aspects, including extent to which local adaptation has occurred, require more study, particularly directed toward larval occurrences and comparisons with other habitats in the surrounding landscape.

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First Records of the Yellow Bullhead, *Ameiurus natalis*, a Loricariid Catfish, *Panaque suttonorum*, and a Silver Pacu, *Piaractus* cf. *P. brachypomus*, in British Columbia

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In Canada, there are no native catfish west of the continental divide and until recently, the list of extant exotic catfishes in British Columbia only included introduced Black Bullhead (*Ameiurus melas*) and Brown Bullhead (*Ameiurus nebulosus*). We report that a single Yellow Bullhead (*Ameiurus natalis*) was collected from Silvermere Lake in the Lower Fraser River drainage. This represents the first record of the Yellow Bullhead in western Canada, and its introduction likely was accidental with a shipment of Largemouth Bass (*Micropterus salmoides*) rather than dispersal from Washington. Warm, eutrophic, weedy habitat in the Fraser Delta provides ample habitat for Yellow Bullheads and other exotic fishes. A Blue-eyed Panaque (*Panaque suttonorum*), a loricariid catfish found in 1995 in Shawnigan Lake, Vancouver Island, probably represents a single, illegally released aquarium fish, as does a large Silver Pacu (*Piaractus* cf. *P. brachypomus*), which was found in Green Lake on Vancouver Island in 2004.

Key Words: Yellow Bullhead, *Ameiurus natalis*, Blue-eyed Panaque, *Panaque suttonorum*, Silver Pacu, *Piaractus* sp., exotic introductions, British Columbia.

Most populations of native species were established in British Columbia during and after deglaciation, but this slow process of natural colonization and dispersal pales in comparison to the wave of accidental and intentional species introductions in the province since the arrival of Europeans. Escaped pets, intentionally released pets, the illegal and intentional release of exotic game fishes by local fishermen, intentional release of game fishes by government agencies, contaminants in poorly sorted shipments of game fish, and northward dispersal of fishes introduced in Washington, now are the principal sources of exotic freshwater fishes in British Columbia. The pathways used to enter the province and the dispersal potential once present, varies with each species.

Carl and Guiguet (1957), Carl et al. (1967), Scott and Crossman (1973), Hart (1973), Crossman (1991), Coad (1995), Moyle (2002), and Wydoski and Whitney (2003) detail the exotic fish species (or hybrids) known to have been introduced into British Columbia prior to this report (Table 1). Approximately 7.4% of the exotic fishes in Table 1 are ornamental (including Mosquitofish [*Gambusia affinis*] and Fathead Minnows [*Pimephales promelas*] introduced for mosquito control; Fathead Minnows also may be introduced illegally as live bait, or dispersed into the province via the Peace River drainage [Smith and Lamb 1976]), 24.1% are non-game fishes (e.g., stickleback, Redside Shiners [*Richardsonius balteatus*]), and 68.5% are game/food fishes and hybrids between game fish species. In many cases, fishes that are native to the province (or their hybrids) are legally stocked in new locations to enhance local fisheries and satisfy anglers (e.g., Walleye [*Sander vitreus*], Rainbow Trout [*Oncorhynchus mykiss*], West-slope Cutthroat [*O. clarki lewisi*], and Pacific salmon [*O. gorbuscha*, *O. nerka*, *O. keta*, *O. kisutch*, *O. tshawytscha*]), and in others, game fishes are illegally introduced to new waterbodies by private individuals (e.g., Northern Pike [*Esox lucius*], Smallmouth Bass [*Micropterus dolomieu*]) (McPhail and Carveth 1994). While most fishes released in this province are game fishes, it is likely that the number of exotic aquarium fishes released in British Columbia will grow with the burgeoning pet trade (see Padilla and Williams 2004).

Species Accounts

Silver Pacu (*Piaractus* cf. *P. brachypomus*) – Family Characidae (tetras)

On 4 June 2004, a large pacu was caught by a Federal Fisheries Officer angling in Green Lake (~49°13'50"N, 124°03'39"W) near Nanaimo (Figure 1). This fish likely is a Silver Pacu (Figure 2), although initially it was thought to be a piranha (*Serrasalmus* sp./*Pygocentrus* sp.) and subsequent media reports called the fish a Red-bellied Pacu (a commonly used name in the pet trade). The species identity as used in this report cannot be verified unless the body is located

TABLE 1. Fishes introduced British Columbia according to Wydoski and Whitney (2003), Moyle (2002), Coad (1995), Crossman (1991), Hart (1973), Scott and Crossman (1973), Carl et al. (1967), and Carl and Guiguet 1957, and Royal British Columbia Museum (RBCM) collection records; EX = exotic introductions, NA = native populations also in BC, MM = man-made hybrids or hybrids in nature due to stocking of exotics.

Family	Species	Common Name	Status
Petromyzontidae	species not mentioned		?
Acipenseridae	*Acipenser transmontanus*	White Sturgeon	NA
Amiidae	*Amia calva*	Bowfin	EX
Hiodontidae	*Hiodon alosoides*	Goldeye	NA
Clupeidae	*Alosa sapidissima*	American Shad	EX
Cyprinidae	*Couesius plumbeus*	Lake Chub	NA
	Platygobio gracilis	Flathead Chub	NA
	Notropis hudsonius	Spottail Shiner	NA
	Pimephales promelas	Fathead Minnow	EX
	Richardsonius balteatus	Redside Shiner	NA
	Tinca tinca	Tench	EX
	Cyprinus carpio	Common Carp	EX
	Carassius auratus	Goldfish	EX
Catostomidae	*Catostomus catostomus*	Longnose Sucker	NA
	Catostomus commersoni	White Sucker	NA
Ictaluridae	*Ameiurus melas*	Black Bullhead	EX
	Ameiurus nebulosus	Brown Bullhead	EX
	Ictalurus punctatus	Channel Catfish	EX
Salmonidae	*Oncorhynchus mykiss*	Rainbow Trout	NA
	Oncorhynchus mykiss aguabonita	California Golden Trout	EX
	Oncorhynchus clarki lewisi	West-slope Cutthroat	NA
	Oncorhynchus clarki lewisi × *O. mykiss*		NA MM
	Oncorhynchus keta	Chum Salmon	NA
	Oncorhynchus nerka	Sockeye Salmon	NA
	Oncorhynchus tshawytscha	Chinook Salmon	NA
	Salvelinus alpinus	Arctic Charr	EX
	Salvelinus fontinalis	Brook Trout	EX
	Salvelinus malma	Dolly Varden	NA
	Salvelinus fontinalis × *S. malma*		MM
	Salvelinus fontinalis × *S. confluentus*		MM
	Salvelinus fontinalis × *S. namaycush*		MM
	Salvelinus namaycush × *S. malma*		MM NA?
	Salvelinus namaycush × *S. confluentus*		MM NA?
	Salmo salar	Atlantic Salmon	EX
	Salmo trutta	Brown Trout	EX
	Thymallus arcticus	Arctic Grayling	NA
	Coregonus clupeaformis	Lake Whitefish	NA
Esocidae	*Esox lucius*	Northern Pike	NA
Gasterosteidae	*Culaea inconstans*	Brook Stickleback	NA
	Gasterosteus aculeatus	Threespine Stickleback	NA
Gadidae	*Lota lota*	Burbot	NA
Percopsidae	*Percopsis omiscomaycus*	Troutperch	NA
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	EX
	Poecilia reticulata (?)	Guppy	?
	Xiphophorus helleri	Swordtail	EX
Moronidae	*Morone saxatilis*	Striped Bass	EX
Centrarchidae	*Micropterus dolomieu*	Smallmouth Bass	EX
	Micropterus salmoides	Largemouth bass	EX
	Lepomis macrochirus	Bluegill	EX
	Lepomis gibbosus	Pumpkinseed	EX
	Pomoxis nigromaculatus	Black Crappie	EX
Percidae	*Perca flavescens*	Yellow Perch	EX
	Sander vitreus	Walleye	NA
Cichlidae	*Tilapia* sp.	Tilapia	EX

and examined in detail. Furthermore, only estimates of size can be taken from images and notes provided by staff of British Columbia, Ministry of Water, Lands, and Air Protection (now Ministry of Environment). The fish measured about 40 cm total length, and 35 cm fork length, and had been feeding on aquatic vegetation based on its gut contents (milfoil was the dominant item in the gut) [M. deLaronde, personal communication, 2005].

Blue-eyed Panaque

(*Panaque suttonorum*) – Family Loricariidae (suckermouth armoured catfishes)

The Royal British Columbia Museum fish collection contains a single Blue-eyed Panaque (RBCM 996-190-001) (Figure 3), which was collected in 1995 from a ditch where Royce Road crosses Shawnigan Creek (approximately at 48°40'05", 123°37'32") (Figure 1). The creek leads into the north end of Shawnigan Lake, Vancouver Island. The specimen is 21.8 cm total, and 19.2 cm fork length. This specimen originally was misidentified as *Hypostomus plecostomus* when it was received in 1996.

Yellow Bullhead

(*Ameiurus natalis*) – Family Ictaluridae (North America Freshwater Catfishes)

The first Yellow Bullhead found in British Columbia (Figure 4) was collected on 21 July 2005, by electrofishing the southeast corner of Silvermere Lake (49°10'01"N, 122°24'27"W) (Figures 1 and 5). The Yellow Bullhead was in stained but clear water about 10 cm deep, and emerged from a clump of submerged, algae-covered terrestrial grass which was approximately 30 cm offshore; the water in the bay was 29.5°C at the surface. The specimen (RBCM 005-079-001) was anaesthetized/euthanized with 2-phenoxy ethanol, prior to fixing in 10% formaldehyde. It is possible that other Yellow Bullheads have been caught in this lake, but were not recognized as different from Black or Brown Bullheads by local anglers. The specimen is 12.9 cm total length and 10.7 cm standard length. The following features from identification keys in Scott and Crossman (1973, page 589), Becker (1983, pages 143-145), Moyle (2002, pages 85-86), and Wydoski and Whitney (2003, pages 153-154), confirm the identification of the Yellow Bullhead from Silvermere Lake: body lacks spots or blotches; lower jaw does not project beyond upper jaw; distance between isthmus and lower jaw notch is less than the distance between the lower jaw notch and the tip of the lower jaw (see illustrations in Scott and Crossman 1973, page 589); mental barbels yellow-white without melanophores; depressed anal fin overlaps leading edge of caudal fin; and caudal fin with round trailing margin.

Yellow Bullheads are native to Atlantic and Gulf Slope drainages from New York to Mexico, the St. Lawrence River, the Great Lakes, and the Mississippi River Basin from North Dakota to the Gulf of Mexico (Scott and Crossman 1973; Lee et al. 1980), and they have been introduced to at least 14 states outside of their native range (Fuller et al. 1999). They also are known from headwaters of the Hudson Bay drainage in Minnesota but have not been found downstream in Manitoba to date (Koel and Peterka 1994; Stewart et al. 2001; Stewart and Watkinson 2004).

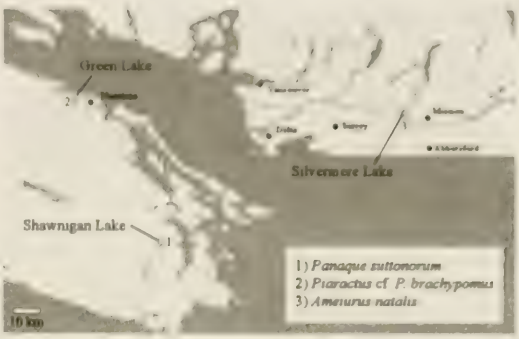

FIGURE 1. A map showing the general location of the three new records mentioned in this report, relative to southern Vancouver Island and the Fraser River delta; scale bar = 10 km.

FIGURE 2. The single Silver Pacu (*Piaractus* cf. *P. brachypomus*) taken from Green Lake, Vancouver Island, 4 June 2004; surrounding parts of image (stainless-steel tabletop) cropped to simplify the illustration. Scale bar = 5 cm.

FIGURE 3. A photograph of the preserved *Panaque suttonorum* specimen (RBCM 996-190-001) collected from the Shawnigan Lake area, Vancouver Island; surrounding parts of image (dissection tray) cropped to simplify the illustration. Scale bar = 5 cm.

Discussion

Two of the three species documented in this report are not threatening to the ecology of British Columbia, especially since they are tropical and appear to result from the release of single fish rather than groups, which could form breeding populations. However, all three species are unnecessary additions to the provincial ichthyofauna, and there always is a risk that exotic introductions may carry unknown pathogens which may infect native fishes (e.g., Dove and Ernst 1998; Yamamoto and Tagawa 2000; Font 2003).

In British Columbia, a large portion of the northern waterways are fast-flowing, cool to cold glacier-fed streams and oligotrophic lakes running through montane areas, and as such, are inhospitable to warm water adapted exotic organisms. However, many exotic species can survive in the southwestern region for a summer or longer, and fortunately, cold meltwater from higher elevation may limit their long-term survival and dispersal. In some regions (e.g., the Okanagan, the Lower Fraser River Valley, and southern Vancouver Island), there are many ponds, ditches, reservoirs, and slowly flowing low-gradient streams running through agricultural land that may support a range of exotic species, and in places, may be warm enough in summer to allow tropical species to breed. The mild climate of southwestern British Columbia already is hospitable to a wide range of organisms presently in the pet trade (e.g., fishes such as *Lepisosteus osseus*, *L. platostomus*, *L. oculatus*, *Ictalurus punctatus*, *Clarias* sp., *Tanichthys albonubes*, *Rhodeus* sp., *Cyprinella lutrensis*, *Carassius auratus*, *Cyprinus carpio* [koi], *Myxocyprinus asiaticus*, *Misgurnus anguillicaudatus*, *Gastromyzon* sp., and some hillstream loaches [Homalopteridae]) or fishes imported live to Canada for human consumption (e.g., *Tilapia* sp., *Sarotherodon* sp., *Oreochromis* sp., *Channa* sp., *Hypophthalmichthys* sp., and *Monopterus* sp.). Given predictions of warming aquatic environments in North America (Mandrak 1989; Meisner 1990; Rahel et al. 1996; Eaton and Scheller 1996; Schindler 2001; Stefan et al. 2001; Jackson and Mandrak 2002; Vander Zanden et al. 2004) it is likely many more exotics could become established in the waterways of this province; those that already are present in Canada likely will expand their range northward where habitat and water flow permits.

Characid Fishes

The large size of most pacu and related "silver dollar" species limits their suitability for home aquaria, and likely is the reason why they are occasionally released in North America. Fuller et al. (1999) discuss a variety of pacu and silver dollars (*Colossoma* sp., *Metynnis* sp., *Myleus* sp., *Piaractus* sp.), which have been found outside of captivity in many of the United States including Washington. Coad (1995, page 11) noted that a specimen of *Colossoma bidens* was found in Ontario (although the location was not given), and Renaud and Phelps (2001) mention another pacu which was found in the Rideau Canal, Ontario. It is not known if there are any wild/naturalized reproducing populations of pacu and silver dollars in North America (Fuller et al. 1999).

Apparently the Silver Pacu found in Green Lake on Vancouver Island was the second pacu to be collected in British Columbia; the first was taken from the Lower Mainland a few years earlier (R. Dolighan, personal communication, 2005), but no detailed reports or literature references to this fish exist. It has been suggested that the Silver Pacu from Green Lake was from a large display aquarium in a local restaurant. The other pacu in the display aquarium also may have been released when the restaurant closed down, but attempts to locate other specimens in Green Lake were unsuccessful. The intentional release of large, unwanted aquarium pets (including large piranha [probably *Pygocentrus nattereri*] which may have been released into Langford Lake on Vancouver Island [T. Duce, personal communication, 2005]) is a continuing threat to British Columbia's waterways, and a threat which is difficult if not impossible to control. Piranhas such as *P. nattereri* have been found in the wild as far north as Minnesota, Idaho, and the Columbia River in Washington (Fuller et al. 1999). Fortunately pacu and piranha usually are kept in small numbers or singly, and so any released specimens are unlikely to find mates and reproduce, even if they survive in British Columbia's waters.

Loricariid Catfishes

Some loricariid fishes ("plecostomus") can tolerate cool water aquaria and commonly are kept with goldfish in home aquaria, as are weatherloaches (*Misgurnus anguillicaudatus*), and surprisingly, it is the expensive *Panaque* species, not the inexpensive *Hypostomus*, which have been found in the wild in Canada. In addition to the single Blue-eyed Panaque from British Columbia, a single specimen of the Royal Panaque or Royal "Pleco" (*Panaque nigrolineatus*), is known from southern Ontario (Coad 1995, page 11). Both the Royal Panaque and the Blue-eyed Panaque are native to South America and are unlikely to survive long in Canada's present climate, unless they are released downstream of hotsprings or near warm industrial effluent (the same can be said for most tropical fishes, including pacu). Illegally released tropical aquarium fishes persist in Alberta downstream of hotsprings despite cold winters in that province (Nelson and Paetz 1992), and the possibility of tropical fish introductions is a persistent threat to hotsprings in British Columbia.

Ictalurid Catfishes

Washington state waterways contain several ictalurid species, including: Blue Catfish (*Ictalurus furcatus*), Channel Catfish (*I. punctatus*), Tadpole Madtom (*Noturus gyrinus*), Flathead Catfish (*Pylodictis olivaris*), White Catfish (*Ameiurus catus*), Yellow Bullhead (*A. natalis*), Black Bullhead (*A. melas*), and Brown Bull-

head (*A. nebulosus*) (Wydoski and Whitney 2003). None of these fishes are native to the state and exhibit varying degrees of success in Pacific slope drainages. Black, Brown, and Yellow Bullhead catfishes now are found all over Washington (Wydoski and Whitney 2003), but since casual observers find the three species difficult to differentiate, it is likely that the true range of each is underestimated.

Carl et al. (1967), Scott and Crossman (1973), McPhail and Lindsey (1986), McPhail and Carveth (1994), and Coad (1995) detail the distribution of catfishes in British Columbia and until this year, researchers thought that only the Black Bullhead and Brown Bullhead existed in this province. As in Washington, the range of Black and Brown bullheads likely is underestimated because of the difficulty of identification, and limited survey sampling in appropriate habitat.

Yellow Bullheads are hardy, and given their presence in the Columbia River system and the Olympic Peninsula in Washington (Wydoski and Whitney 2003), it was only a matter to time before they appeared in British Columbia. It is possible that Yellow Bullheads were introduced to British Columbia as a contaminant in an unsorted or poorly sorted shipment of Largemouth Bass. The electrofishing sample from Silvermere Lake taken on 21 July 2005 contained the single Yellow Bullhead, 1 Brown Bullhead, 5 Pumpkinseeds (*Lepomis gibbosus*), 28 Prickly Sculpins (*Cottus asper*), 30 Black Crappie (*Pomoxis nigromaculatus*), and 57 Largemouth Bass (*Micropterus salmoides*). Note that only one species (*Cottus asper*) in the six caught in Silvermere Lake is native to the Fraser River drainage, and that single native species made up only 23% of the catch.

The date of introduction of Brown Bullheads into British Columbia is unknown, but they were stocked in Washington from 1874 onwards, and those on Vancouver Island date back to 1906 (Carl and Guiguet 1957; Carl et al. 1967; Wydoski and Whitney 2003). According to anecdotal evidence, the initial stocking in Beaver Lake on Vancouver Island was accomplished from the window of a passing train, and these few bullheads were from an aquarium displayed in a local restaurant (Carl and Guiguet 1957; Carl et al. 1967). Langford Lake and other lakes were stocked soon after, from the Beaver Lake population. It is possible that Black Bullheads were a contaminant in the early stocks of Brown Bullhead since the two species can be difficult to differentiate, especially when young (Becker 1983; Lever 1996). However, if present, Black Bullheads failed to reproduce and were extirpated while the Brown Bullhead survived on Vancouver Island.

Bullhead catfish have not spread far in British Columbia because the warm, eutrophic conditions they require are found only in lakes and ponds of southern Vancouver Island, the Fraser River Delta, and the southern portions of the Columbia River drainage in this province. Where they have been introduced, bullheads are reputed to be effective nest predators, and have been implicated in the elimination of Threespine Stickleback (*Gasterosteus aculeatus*) populations in smaller lakes along the coast (McPhail and Lindsey 1986). Male stickleback cannot repel intruding adult bullheads, and in one lake near Mission, a large population of sticklebacks went extinct only two years after bullheads were introduced (McPhail and Lindsey 1986; Wydoski and Whitney 2003). The addition of the Yellow Bullhead (*Ameiurus natalis*) to

FIGURE 4. Photographs of (A) the live Yellow Bullhead (*Ameiurus natalis*) just after capture, and (B) the same specimen once preserved (RBCM 005-079-001); ruler in (B) is in centimetres.

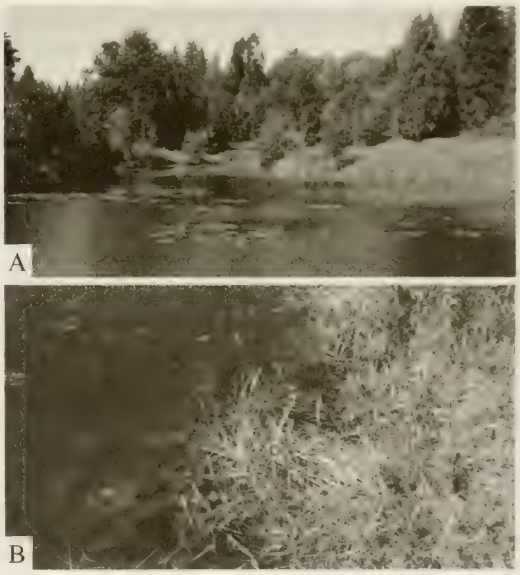

FIGURE 5. The southeast bay on Silvermere Lake just north of Highway 7 (A) and detail of shoreline habitat (B) where the Yellow Bullhead was collected.

British Columbia's aquatic biota is not to be celebrated, and probably represents one more case of a contaminant species accidentally released with a transplant of game fish.

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Regional Variation in *Amelanchier* in the Whitewood area of Southeastern Saskatchewan and the First Saskatchewan Records of *Amelanchier sanguinea*

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Based on measurements and evaluation of 111 specimens from 51 localities in the Whitewood area of southeastern Saskatchewan, most *Amelanchier alnifolia* from the prairie parkland is represented by short, stoloniferous shrubs, less than 2 m tall with 5 – 100+ stems. In the Moose Mountain area, *A. alnifolia* is represented by shrubs that are taller, sometimes to 7 m, not stoloniferous and usually having fewer than five stems. Although many of these plants have the inflorescence characteristics of *A. alnifolia*, some are referable to the eastern *A. sanguinea*, not previously reported from southeastern Saskatchewan. Such plants appear to be confined to the wooded environment of Moose Mountain. *Amelanchier alnifolia* is not as clearly differentiated by habit or leaf tip characteristics as the literature suggests. Inflorescence characteristics, habit and actual genetic variation may be associated with biogeographic patterns, especially historically wooded islands within the prairie ecozone. These patterns are an important consideration in classification studies and in protecting and utilizing *Amelanchier* germplasm.

Key Words: Juneberry, Serviceberry, Shadbush, Saskatoon, *Amelanchier alnifolia*, *A. sanguinea,* status, biogeophaphic variation, hybrid, agamospermy, Moose Mountain, Saskatchewan.

At least three species of *Amelanchier* are known to occur in the prairie region of Canada. *Amelanchier alnifolia* (Nutt.) Nutt. is widespread, *Amelanchier florida* Lindl. is confined to ravines in the Cypress Hills (reported by some authors and not by others) and *A. sanguinea* (Pursh) DC. occurs in southeastern Manitoba (e.g. Boivin 1967; Looman 1979). Reports of *A. sanguinea* from the northern Great Plains (Stephenson 1973; McGregor et al. 1977) are based on *A. humilis* Wieg. (McGregor et al. 1986), whereas Boivin's (1967) report of *A. sanguinea* in southeastern Manitoba may be based on material of both *A. sanguinea* and *A. humilis* since he combined the latter with the former and both occur in the general region and in northern Minnesota (Nielsen 1939; Jones 1946).

In general, flowering material of *A. sanguinea* is distinguished from *A. alnifolia* by having flowering pedicels more than 15 mm long instead of less than 10 mm long (Boivin 1967; Cinq-Mars 1971; Gleason and Cronquist 1991) and petals 11-22 mm long instead of 6-10 mm long (e.g., Jones 1946). In addition, *A. sanguinea* is characterized as a tree with oblong, pointed leaves and *A. alnifolia* is generally characterized as a stoloniferous shrub with truncate or rounded leaves (e.g., Nielsen 1939; Jones 1946; Fernald 1950). *Amelanchier humilis* is distinguished from *A. alnifolia* by its acute or obtuse instead of truncate or broadly rounded leaves (Cinq-Mars 1971; McGregor et al. 1986). McGregor et al. (1986) have indicated that it is difficult to separate *A. alnifolia* and *A. humilis* in the northern Great Plains and they have suggested that some colonies "appear as hybrid swarms and the two could easily be considered as variants of one species." The concept of including *A. humilis* with *A. alnifolia* is not new since it was the basis for McKay's (1973, 1975, 1976) transfer of Nielsen's *A. humilis* var. *compacta* to *A. alnifolia* (*A. alnifolia* var. *compacta* (Nielsen) McKay).

During a survey of *Amelanchier* in the Whitewood and Moose Mountain areas of southeastern Saskatchewan in early June 2005, it appeared that plants in the prairie-parkland region (ecodistricts 752, 756, 760, Agriculture and Agri-Food Canada 1995) differed from those on the elevated Moose Mountain plateau (ecodistrict 761) which was forested in presettlement times (Catling and Kostiuk 2006). This rolling plateau, almost 400 km^2 in extent with numerous lakes and well-drained wooded slopes with aspen (*Populus*) and birch *(Betula)* forest, is 100 – 150 m above the surrounding plains.

The objective of the work reported here was to document the variation and to provide a context for the first report of *Amelanchier sanguinea* in Saskatchewan. This information is relevant to systematic studies of *Amelanchier* and is also of interest with regard to the protection of native *Amelanchier* germplasm. Although Saskatoon (*Amelanchier alnifolia*) is one of Canada's fastest growing native crops, its variation is not well understood and its domestication has yet to take advantage of the full range of variability available (Catling and Small 2003).

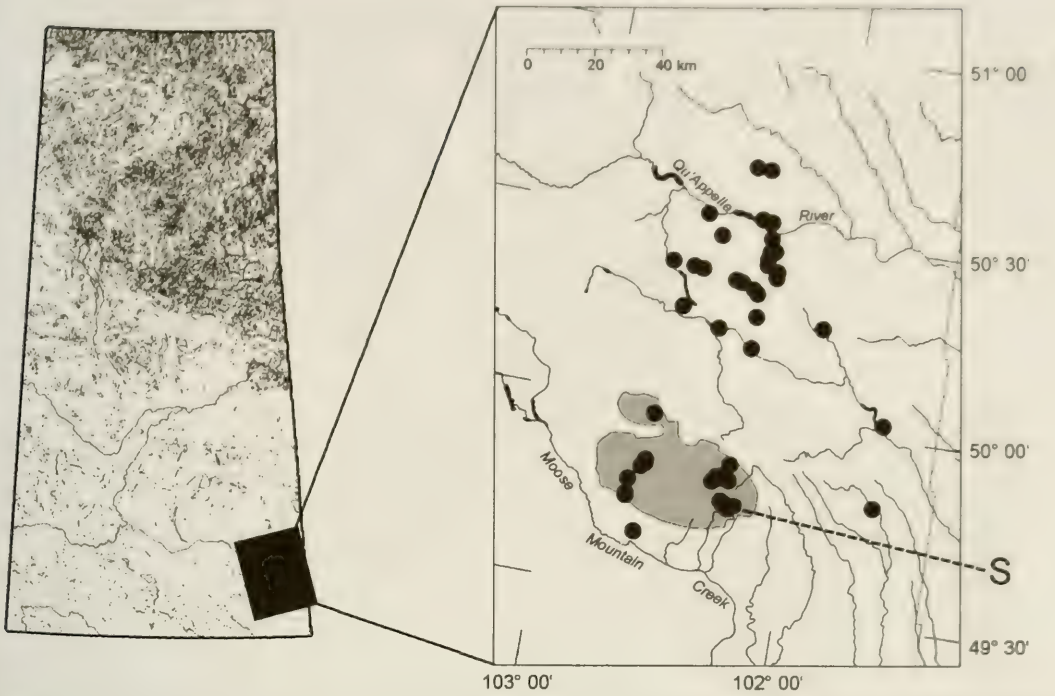

FIGURE 1. Saskatchewan (left) showing location of Whitewood study area (right). Collection localities of *Amelanchier* used in the study are indicated by dots. The Moose Mountain ecodistrict is shaded. The collection site of *A. sanguinea* is indicated by "S" and dashed line connected to the dot.

Methods

In June 2005, during late flowering, 111 specimens of *Amelanchier* were collected and measured from 51 sites in the Whitewood – Moose Mountain area of southeastern Saskatchewan (Figure 1). No more than five specimens were collected at each site and sites are defined as at least 0.1 km apart. Specimens were selected to represent the extremes of variation present at a site. For each specimen, lengths of lowest pedicel in an inflorescence of average size, average petal length in lowest flower in the inflorescence, average sepal length in lowest flower in the inflorescence, the plant habit (stoloniferous or not, height, number of stems), leaf pubescence (scale 1-4, 1 = glabrous, 4 = densely pubescent) and shape of the tip of a larger leaf (scale 1-5 with 1 = truncate, 5 = pointed). Stoloniferous shrubs were defined as having more than 6 separated stems and being less than 2 m in height. Non-stoloniferous shrubs were defined as having 5 or fewer stems together and exceeding 2 m in height.

The data were analysed using Principal Components Analysis (PCA), regression and histograms. PCA reduced dimensionality of six characters (Table 1), to two allowing for an evaluation of grouping and indication of pattern of variation. Histograms evaluated pedicel length with respect to habitat for different ecodistricts. F-ratios based on the comparison of the mean square variance of the regression model to the mean square of the residual indicated relationship and significance of individual characters noted above. Statgraphics software (www. statgraphics.com) was used to perform all the statistical analyses.

Results and Discussion

On the PCA plot (Figure 2) that reduces the dimensionality of six characters, the first two components account for 32.53% and 25.75% of the sample variation and the third and fourth account for 16.90% and 11.68%, respectively. On the first component, pedicel length, sepal length and height are heavily weighted whereas on the second component, leaf tip and leaf shape are heavily weighted. Leaf pubescence was not heavily weighted on either of the first two components. With a cumulative 58.28% of the sample variation accounted for in the diagram, the plot is marginally useful as an indication of potential groups, and groups are unclear. However, the plants from historically wooded Moose Mountain area occupy a specific part of the dispersion suggesting a different pattern of morphological variation from that represented elsewhere in the region.

The plants from Moose Mountain tend to have longer pedicels, and they are mostly non-stoloniferous (Figure 3). Variation in leaf tip shape, overall leaf shape, leaf pubescence and the inflorescence characters is extensive. Most plants on Moose Mountain that are presumably *A. sanguinea* on the basis of height and non-stoloniferous habit have to be treated as *A. alni-*

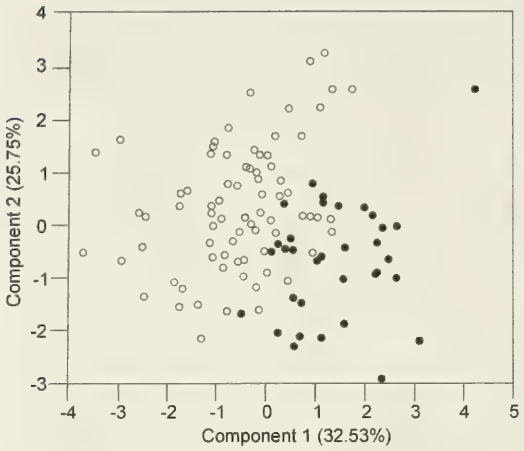

FIGURE 2. Plot of 111 specimens used in the study on the first two principal components derived from correllation among six morphological characters. The specimens from Moose Mountain are shown with solid dots and these occupy a specific portion of the dispersion suggesting distinctive variation within this region.

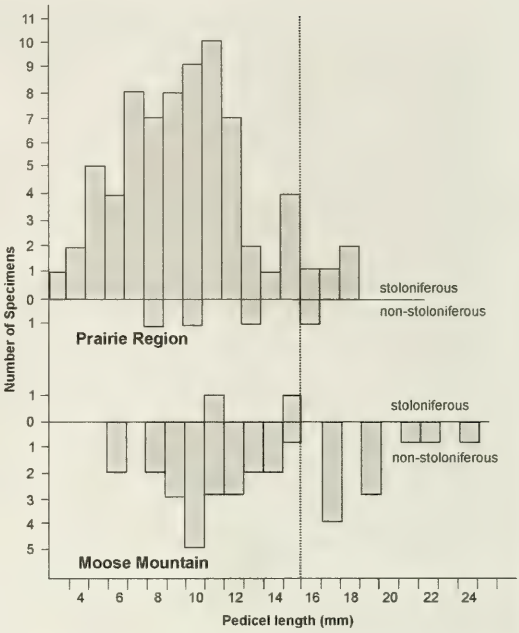

FIGURE 3. Histograms showing pedicel lengths and growth habits for specimens of *Amelanchier* from the prairie region and the Moose Mountain region of southeastern Saskatchewan.

folia on the basis of pedicels less than 15 mm long and petals less than 10 mm long. The ten plants potentially referable to *A. sanguinea* on the basis of pedicels over 15 mm (Figure 3) had leaves with variable tips. For example five shrubs had more or less truncate leaves, four had most leaves broadly rounded and two had many pointed leaves. Leaf shapes also varied. Eight of these are moderately pubescent but two are more or less glabrous. All of these ten had petals over 9 mm but under 12 mm long. The two specimens accepted as *A. sanguinea* (e.g., Figure 4 left) had pedicels 17 mm, petals 11-12 mm, pointed, moderately pubescent, oblong leaves. These two plants were distinctive in blooming later than other plants nearby that possessed fewer *A. sanguinea* characteristics. The specimen label data for these are: SASKATCHEWAN: Moose Mountain: White Bear Lake, 49.7550°N, 102.2565°W, 8 June 2005, *P. M. Catling 05-27, B. Kostiuk* (DAO); Good Bird Point, White Bear Lake, 49.7639°N, 102.2328°W, 6 June 2005, *P. M. Catling 05-16, B. Kostiuk* (DAO). *Amelanchier sanguinea* has not been reported previously from Saskatchewan (Harms 2003).

Amelanchier alnifolia from the prairie parkland is represented mostly by short, stoloniferous shrubs, less than 2 m tall with 5–100+ stems, but taller, non-stoloniferous shrubs also occur in poplar groves. The smaller stoloniferous plants often have distinctively short and dense racemes with pedicels little if at all longer than the petals (Figure 4, right). The leaves may be truncate or more or less pointed.

The regressions indicated that pedicel length had the most significant relationships with other characteristics and was significantly correlated with ecodistrict (Table 1). Sepal length was also significantly correlated with other characters, but was not significantly associated with leaf tip which is regarded as a significant character for distinguishing *A. alnifolia* by some authors (see above). In overall addition of significance values, pedicel length was three time more significant than sepal length. Futhermore, sepals are more often damaged or shrunken (as in fruit) whereas pedicels are more often intact. This represents the first quantitative support for the use of pedicel length in defining taxa. Leaf shape was only highly correlated with leaf tip and was not significantly related to ecodistrict suggesting limited use in defining taxa. These suggestions are based on the operational concept of taxa being defined by a number of correlated morphological characters and by some ecological discreteness. Thus the more recently defined (see above) characters are supported and these are included in the following key which will differentiate the four species known from the prairie provinces.

1a. Pedicels short, less than 10 mm long; petals 4-10 mm long; mostly stoloniferous shrubs 2
2a. Leaves glabrous or sparsely tomentose at flowering, truncate or broadly rounded . . . *A. alnifolia*
2b. Leaves persistently pubescent at flowering, obtuse to acute . . . . . *A. humilis*
1b. Pedicels longer, over 15 mm long; petals 11-22 mm long; non-stoloniferous shrubs 3
3a. Leaves glabrous at flowering . . . . . *A. florida*
3b. Leaves more or less tomentose at flowering . . . . . *A. sanguinea*

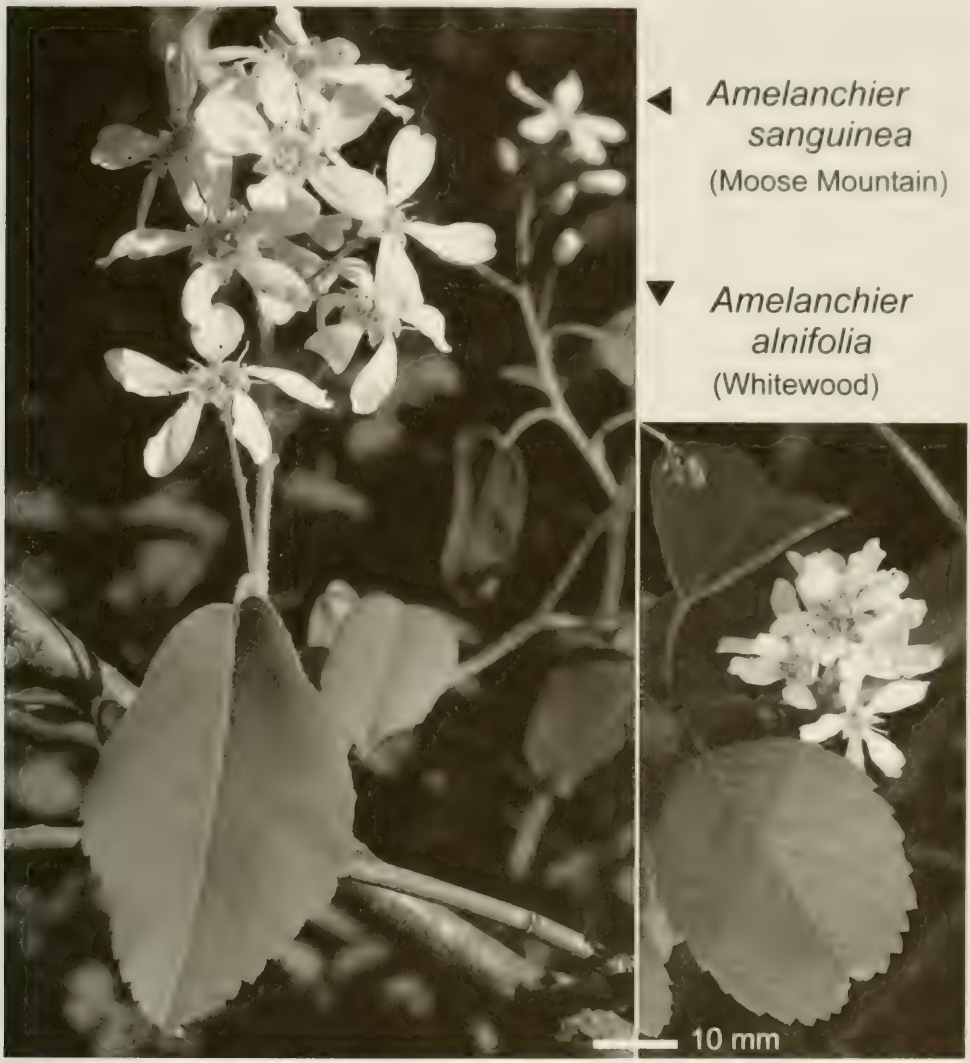

FIGURE 4. *Amelanchier sanguinea* from Moose Mountain, near White Bear Lake (left) with relatively long pedicels and open inflorescence and pointed oblong leaves. *Amelanchier alnifolia* (right) from relict prairie along the railway west of Whitewood with a dense infloresence, relatively short pedicels and a truncate and rounded leaf.

It appears that *A. sanguinea* is uncommon in the Moose Mountain upland whereas hybrids with *A. alnifolia* that have inflorescence features of *A. alnifolia,* and other characters in various combinations, are frequent. In many cases the difficulty in identifying *Amelanchier* material has been attributed to hybridization, introgression and agamospermy (e.g., Robinson 1982; Campbell and Wright 1996) but this aspect has yet to be investigated in the prairie region. There is much more variation in plants referred to *A. alnifolia* than was previously suspected. This variability appears to have a pattern to some extent associated with biogeographic boundaries. The correlation with biogeography may provide a useful basis for the utilization and protection of germplasm and it may also provide a means of determining groups and optimal characters in future taxonomic studies.

It is possible that differentiation of *Amelanchier* related to forested or unforested habitats in central North America has been going on for many thousands of years and that this phenomenon spread into southeastern Saskatchewan from the south following melting of the continental glacier about 10 000 years ago. Plants corresponding to *Amelanchier sanguinea* may have been present in the Moose Mountain area with early postglacial poplar- or spruce (*Picea*) dominated

TABLE 1. Significance of F-ratios from simple regression for seven characteristics of *Amelanchier* in the Whitewood area of southeastern Saskatchewan. A significant relationship is defined as below 0.05 and is shown with boldface.

Character	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) pedicel length	–						
(2) leaf tip	0.0679	–					
(3) leaf shape (l/w)	0.1463	**0.0000**	–				
(4) leaf pubescence	0.3619	0.8416	0.7942	–			
(5) sepal length	**0.0009**	0.6304	0.0675	0.9942	–		
(6) height	**0.0000**	0.3648	0.7270	**0.0003**	**0.0000**	–	
(7) ecodistrict	**0.0000**	0.3938	0.2410	0.0675	**0.0000**	**0.0000**	–

forests that were widespread for a short period about 10 000 years ago, prior to replacement by persisting grassland (e.g., Ritchie 1976), which isolated the forested uplands. Alternatively these plants could have invaded after the Moose Mountain forest was isolated. Consumption of seeds by berry-eating birds would allow long-distance dispersal between forest patches. The recent discovery is not an indication of very recent arrival (although that is a possibility); rather it suggests that the classification and ecology of *Amelanchier* on the Canadian prairies is not well understood and requires much more study.

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Observations on the Nesting of the Northern Hawk Owl, *Surnia ulula*, near Timmins and Iroquois Falls, Northeastern Ontario, in 2001

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Patrikeev, Michael. 2006. Observations on the nesting of the Northern Hawk Owl, *Surnia ulula*, near Timmins and Iroquois Falls, northeastern Ontario, in 2001. Canadian Field-Naturalist 120(4): 433–437.

Three breeding pairs of Northern Hawk Owls were observed in northeastern Ontario in the vicinity of Timmins and Iroquois Falls in 2001, and two nests and a brood were recorded. The young from one nest fledged prematurely (likely due to a storm) and the another nest probably failed. Four other territorial pairs were observed. Notes on nest sites, feeding and nest attendance were taken.

Key Words: Northern Hawk Owl, *Surnia ulula*, nesting, northeastern Ontario, clearcuts.

The distribution and biology of the Northern Hawk Owl (*Surnia ulula*) have not been well documented in North America with fewer than 20 papers published on this species by the mid-1990s (Duncan and Duncan 1998). In Ontario, the Northern Hawk Owl breeds in the boreal forest zone south to latitude 48°, with occasional records south to Parry Sound, Algonquin Provincial Park, and Ottawa (Peck and James 1983; Weir 1987). During the first Ontario Breeding Bird Atlas (OBBA), 1981-1985, the Northern Hawk Owl was found in 0.8% of surveyed 10 × 10 km squares, and during the second OBBA (2001-2004) in 4.2% of squares (OBBA, unpublished data, courtesy of A. Heagy, Bird Studies Canada). This increase in records likely resulted from better access in the boreal forest owing to the extensive network of forest access roads built in the 1990s and early 2000s, more effort directed to northern areas, and an influx of Northern Hawk Owls in northwestern (Escott 2002) and northeastern Ontario (personal observation). Only 25 nests were reported to the Ontario Nest Record Scheme by 2004, with 21 nests from northwestern Ontario (Escott 2002; G. Peck, personal communication).

In May 2001, two nests and three additional Northern Hawk Owl territories were recorded in the drainages of the North Driftwood and Mattagami rivers in Crawford Township north of Timmins, Ontario (48°49'48"N, 081°27'14"W). In June, a pair with a brood and another territory were found in the drainage of Shallow River in Wilkie Township, the City of Iroquois Falls (48°32'15"N, 080°27'59"W). All sites were in Cochrane District (Figure 1).

The nests found in Crawford Township (about 1.3 km apart) were in small stands of medium age mixed forest with low density of living trees and many tall hardwood snags, and surrounded by clearcuts. The stands consisted mostly of Black Spruce (*Picea mariana*) and Balsam Fir (*Abies balsamea*), with fewer poplars (*Populus*), American Larch (*Larix laricina*), Jack Pine (*Pinus banksiana*), and Paper Birch (*Betula papyrifera*). A large number of snags likely indicated past herbicide treatment of deciduous trees to allow for more rapid regeneration of coniferous species. In Wilkie Township, a pair with brood occurred in a small stand of poplars defoliated by Forest Tent Caterpillars (*Malacosoma disstria*) and also adjacent to sizable clearcuts. Other territorial Hawk Owls hunted in wetlands (treed fen), burned areas and overgrown clearings. The nests found in 2001 were in cavities at the top of poplar snags, at 7 and 8.5 m above the ground (Number 1 and 2, respectively). Nest Number 1 was in a shallow cavity open from the above, and Number 2 in a cavity open on one side (Figures 2 and 3). Nest Number 1 was near the stand edge, close to a clearcut, and Number 2 was ca. 10 m away from a moderately used road. The nesting site in Wilkie Township was about 20 m from a forest access road.

Nest sites were visited between 19 May and 25 June, and nest Number 1 was observed from an elevated blind on 30 May, 11 and 12 June between 10:45 and 20:30 hours (for a total of 14.5 hours), with 10× binoculars, and a photographic camera fitted with 500 mm lens. It was assumed that the larger owl that spent most of the time on the nest, and cared for the young was female, and the smaller owl that brought food and made territorial calls was male [according to Duncan and Duncan (1998) incubation and brooding of the young in this species is by the female only].

In nest Number 1 incubation lasted to at least 30 May (incubation was presumed because the female remained seated on the nest, changing her position infrequently and was not seen feeding when food was delivered). At least two young in gray down (presumed to be ca. 7 days old) were seen raising heads in that nest on 11-12 June, but the nest was empty when examined on 25 June. High winds with gusts reaching 89 km/hour resulting from the aftermath of Tropical Storm Allison reached the area on 19 June (Environment Canada website: http://www.climate.weatheroffice.ec. gc.ca), and the young might have fledged prematurely because of

FIGURE 1. Location of the 2001 Northern Hawk Owl nesting records from Cochrane District.

wind. At least one young begged for food on 25 June in the nest vicinity, but it could not be located in the thick growth of spruce and Balsam Fir. The young were likely only ca. 14-18 days old when the high winds struck. Elsewhere in North America, the young leave the nest when 20-30 days old (Kertell 1986; Lane and Duncan 1987).

The fate of nest Number 2 was unknown. The female was in the nest cavity and presumably incubating up to 28 May. On 29 May the female was sitting in an incubating posture higher than previously, suggesting that the young might have hatched. On 10 June, both adults were near the nest displaying aggressive behavior and uttering alarm calls, but no owls visited the nest between 07:45 and 10:00 hrs on the following day, 11 June (when observed from a blind), and no young called. Hawk Owls were also observed not far from nest Number 2 on 25 and 30 June, but no alarm or begging calls were heard. Escott (2002) reported a nest failure near a busy logging road in Thunder Bay District, but traffic near this nest was moderate at the most and unlikely had anything to do with the nest's fate.

In the Shallow River Valley breeding area one fledged young was observed on 13 June, and four fledglings at the same site on 23 June. The largest of these young was completely feathered on 23 June when the other three still had some down on heads and bodies (Figure 4). One flew ca. 20 m when approached thus suggesting that it was at least 30 days old (see Duncan and Duncan 1998).

Some information on nesting and feeding behavior of this species was gathered while observing nest Number 1. The female from that nest never left it during several short visits 19 to 29 May, and 3.5 hours of observation on 30 May (presumably incubating). The male was calling (advertising call, Mikkola 1983) from perches in the vicinity. On one occasion the incubating female also uttered an "ulululu" call very similar to advertising call of the male. After the young hatched, the female sometimes left the nest to hunt, or perched in the vicinity (up to ca. 100 m from the nest) calling for food from time to time. On 11 June, during 6 hours of observation, the female was absent from the nest for a total of 73 minutes, and on 12 June (5 hours of observation) for 71 minutes. On average, she was absent for 24 ± 21.9 minutes at a time (range 3-65 minutes, n = 6). These numbers do not include short absences when the female flew off the nest to meet the male delivering food.

During the observation period food was brought to the female between 11:20 and 20:00 hrs. On eight occasions, the male flew directly to the nest, but on 12 June two food transfers occurred outside the nest. The male never lingered, leaving the nest in ca. 10 seconds after passing food to his mate, but he often perched nearby. At nest Number 2, the male was seen deliver-

FIGURE 2. Nesting habitat and nest site of Northern Hawk Owl, *Surnia ulula caparoch*, in Cochrane District of Ontario. Incubating owl could be seen at the top of the snag in the foreground (nest Number 1). Photo by Michael Patrikeev in 30 May 2001.

FIGURE 3. The second nest found in Crawford Township was in a cavity open on one side. Photo by Michael Patrikeev 30 May 2001.

FIGURE 4. This large fledgling Northern Hawk Owl was photographed in Wilkie Township, near Iroquois Falls, on 23 June 2005. Photo by Michael Patrikeev.

ing to the nest once, and twice the food transfer took place outside the nest. Prey delivery intervals at nest Number 1 varied from 49 minutes to 3 hours and 8 minutes (on average 120.4 minutes ± 66.3 minutes, $n = 8$). These were longer than intervals between feeding of fledglings reported by Lang et al. (1991) from northern Manitoba: 48.5 min ± 34.9 SD ($n = 12$, range 10-130 min). Of 10 observed prey items 7 were Meadow Voles (*Microtus pennsylvanicus*), 1 Northern Short-tailed Shrew (*Blarina brevicauda*), and the remaining two were either small mammals or small birds. The male removed heads of some voles before bringing them to the nest, whereas other prey was delivered whole. Prey beheading was also reported by Duncan and Duncan (1998). It was unclear whether the male ate the heads, as no cranial or dental material was found in pellets cast in the vicinity of the nest, although on one occasion, the female swallowed a prey item whole, head first. The female fed the young from beak to beak or held a partially skinned vole over the young's heads allowing them to tear at the carcass (Figure 5).

In southern Cochrane District in 2001, Northern Hawk Owls nested in recent cutovers possibly treated with herbicides to stress regeneration of deciduous trees. These owls are known to utilize clearcuts for nesting (Duncan and Duncan 1998), and they showed preference for chemically treated clearcuts in northwestern Ontario during their influx in the early 2000s (Escott 2002). Clearcuts with tall snags and few shrubs possibly mimic recently burned areas and other open habitats preferred by this species in its core range further north, and provide both nesting sites and open hunting habitat (Duncan and Duncan 1998). Populations of some prey species (e.g., Meadow Vole) may be more numerous in recent cutovers (Sullivan et al. 2004). Clear-cutting in northeastern Ontario will likely create more ephemeral nesting habitat for this species providing that groups of trees and snags remain after cutting.

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FIGURE 5. Pair of Northern Hawk Owls at nest. The male had just delivered a carcass of a Meadow Vole, and the female (on the left) is holding the vole over the youngs' heads allowing them to tear at the carcass (nest Number 1). Photo by Michael Patrikeev' 11 June 2005.

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MtDNA Analyses on Hair Samples Confirm Cougar, *Puma concolor,* Presence in Southern New Brunswick, Eastern Canada

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For the last 40 years, the presence of Cougars (*Puma concolor*) in eastern Canada has been highly controversial. The purpose of this study was to collect physical evidence of Cougars using a passive detection method. Baited hair-traps combined with camera-traps were installed in New Brunswick and Nova Scotia, Canada. DNA analyses on two hair samples confirmed that the species was present in southern New Brunswick in 2003. A footprint photographed after an observation of a Cougar by reliable observers was examined by experts and was consistent with a Cougar footprint. Additional data are required to determine the status of Cougars in the northeastern part of its historical range.

Key Words: Cougar, *Puma concolor*, hair-traps, camera-traps, physical evidence, mtDNA analyses, tracks, eastern Canada.

Historically, the Cougar (*Puma concolor*) was distributed all across the American continent, from southeastern Alaska to southern Argentina and Chile (Parker 1998). It was the most widely distributed terrestrial mammal in the western hemisphere (Godin 1977). The subspecies referred to as Eastern Cougar (*Puma concolor couguar*) was known to occur in Nova Scotia [NS], New Brunswick [NB], Quebec [QC], Michigan, Tennessee and South Carolina (Goldman 1946). While 32 subspecies were initially listed by Goldman (1946), a recent DNA study by Culver et al. (2000) showed that only six genetically distinguishable subspecies are now believed to occur in the western hemisphere, with only one for North America; i.e., *P. c. couguar*. Populations in northeastern America drastically declined at the beginning of the last century (Parker 1998). Weaver et al. (1996) argued that conflicts for resources and land uses may be the main causes of most Cougar extirpation in North America. Previous studies across North America have indicated that road density, urbanization, agriculture and timber harvesting may also limit Cougar expansion (van Dyke et al. 1986; Maehr et al. 2002; Taylor et al. 2002; Dickson et al. 2005).

The status of the Cougar in eastern North America has always been a highly controversial topic (Cumberland and Dempsey 1994). Due to the secretive habits of this species and the highly fragmented regions where few scattered individuals possibly remain, solid evidence (i.e., a dead animal, DNA collected from scat or hair, a clear photograph or indisputable confirmation of authenticated tracks) is difficult to collect, making decision and species-at-risk designation difficult. Provincially, Cougars are listed as undetermined in NS, and endangered in NB. At the federal level, the status of the eastern cougar population was changed from endangered to data deficient in 1998 (Scott 1998*). No reliable estimate of the number of Eastern Cougars has ever been made because authentic, scientifically-based evidence is lacking (Cumberland and Dempsey 1994). However, numerous credible sightings and physical evidences have since then reopened the Eastern Cougar debate. An extensive review carried out by the Committee on the Status of Endangered Wildlife in Canada [COSEWIC] in 1978 leaves little doubt as to the historical presence of Cougars in eastern Canada (van Zyll de Jong and van Ingen 1978*). Today, the major concern of provincial wildlife agencies is whether the reported animals are natives or feral escaped or released captives (Scott 1998*).

While extensive, logistically demanding fieldwork is usually required to search for such a wide-ranging species, this paper focuses on new data obtained for NB through non-invasive detection methods (i.e., baited hair-trap and camera-trap).

Material and Methods

Study Areas

This project was conducted in NB and NS with 12 traps set up in three national parks, i.e., Fundy National Park of Canada [FNP], Kouchibouguac National Park of Canada [KNP] in NB, and Cape Breton Highlands National Park of Canada [CBHNP] in NS. Conservation units being the largest wilderness areas available, they are more likely to shelter wide-ranging top predators than urban or agricultural lands. Two additional

FIGURE 1. Baited hair-trap (n = 14) locations (triangles) in New Brunswick and Nova Scotia, eastern Canada.

traps were installed in remote areas in the Miramichi region (northeastern NB) because sightings from reliable observers (biologists and trappers) were frequently reported to provincial wildlife agents. All traps were located according to the most recent credible sighting report or physical evidence (Figure 1). Four traps were set up in FNP in forested habitats on the rolling upland plateau. FNP (205.9 km^2) is characteristic of the Maritime Acadian Highlands region and is part of the Appalachian Mountain range (Woodley et al. 1998). Three other traps were installed in KNP (239.2 km^2) in northeastern NB. Two traps were installed in coniferous stands, one in a relatively remote area near Black River in KNP's central region, and the other, less than 1 km from human habitations along the southeastern boundary of the park. The last KNP trap was installed in a hilly mixed wood stand 3 along the Major Kollock creek. Finally, five traps were installed in CBHNP (948.0 km^2), the largest protected wilderness area in NS, protecting 20% of northern Cape Breton. Traps were installed based on recent convincing Cougar sightings in deciduous, mixed wood and dead conifer forests. All trap locations had a closed canopy, an important amount of coarse woody debris or a thick leaf litter, and were close to water sources.

Non-invasive detection techniques

Field work began during the fall of 2003. The passive detection methods used entail collecting hairs, tracks, and scats in a non-invasive manner. Baited hair-traps (Figure 2), consisting of 2-m-high posts surrounded by 3 × 3 m^2 squared enclosures, were installed in areas where credible sightings had recently been reported (Figure 1). Two barbed wire strands were stretched around the wooden posts delimiting the enclosure, at 45 cm and 75 cm from the ground respectively. This was intended to catch hair as the animal enters the enclosure, attracted by the species-specific lure. Dripping lure (i.e., Cougar urine obtained from captives, sex unknown) was hung inside the perforated central post and fresh lure was added every month.

In 2004, in an attempt to get photographic records of animals entering the enclosure, we equipped each station with a camera-trap unit which consists of either a 35-mm or a digital camera triggered by an infrared motion sensor. Each camera was fastened to a tree near the scent post, at a height of 1.8 m (Figure 2). Any motion up to 7 m away within an angle of 120 degrees activated the camera. Traps were checked year-round every 4-5 weeks.

DNA analyses

Samples were submitted to a sequence-based analysis of 16S mitochondrial DNA (mtDNA; Johnson and O'Brien 1997). DNA was extracted from hair samples using QIAGEN DNeasy Tissue kits. In order to determine whether DNA samples were from felid or other mammal species (i.e., felids, canids, cervids, 4 mustelids, procyonids, and ursids), 300 base pairs of 16S mtDNA were amplified using Polymerase Chain Reaction (PCR).

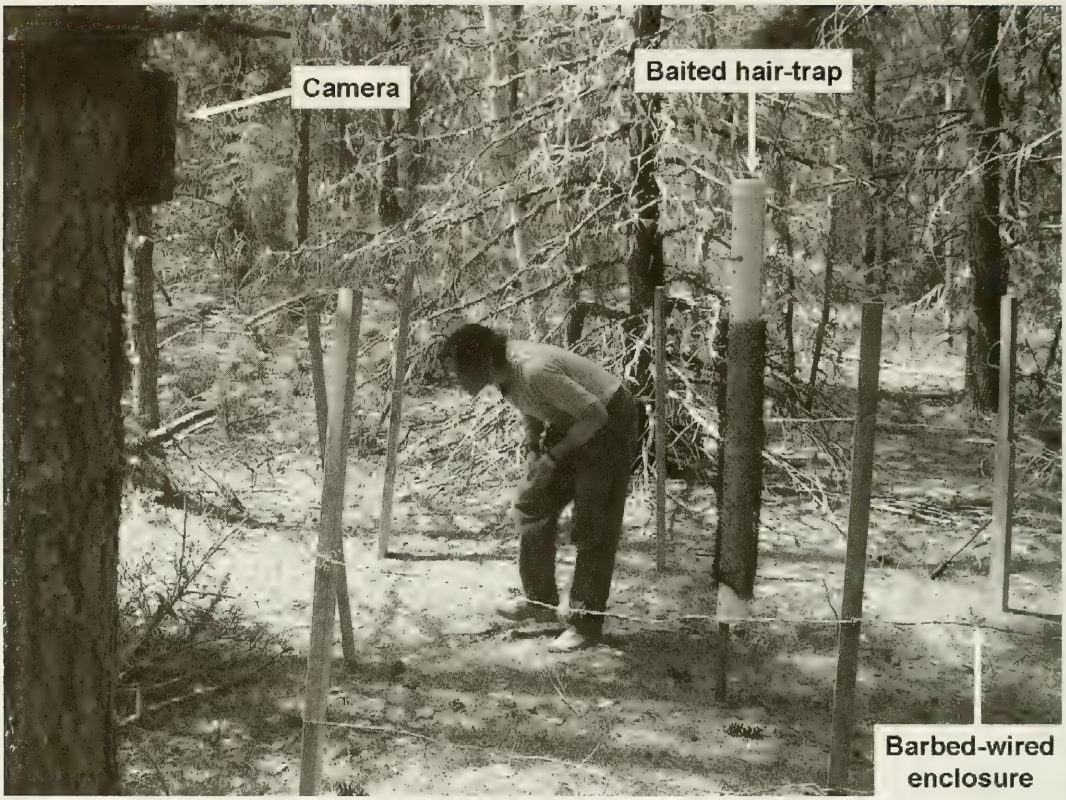

FIGURE 2: Experimental design for Cougar detection, a passive method combining a baited hair-trap (central post and barbed-wired enclosure) protocol and a camera-trap (upper left corner, strapped on a tree).

A volume of 15μL contained 100-500 ng template DNA, 1× reaction buffer, 1.5 mmol (millimoles) $MgCl_2$, 0.3 mmol each primer, 250 mmol dNTPs and 1 U *Taq* polymerase. After initial incubation at 94°C for 2 minutes, 40 cycles of PCR were performed at 94°C for 1 minute, 53°C for 1.5 minutes, 72°C for 1.5 minutes, and 72°C for 10 minutes. Results were then visualized on a 2.0% agarose gel and compared to 20 species from the six families cited above. A second amplification of 600 bp of a specific region of the 16S mtDNA was then conducted according to the protocol detailed by Mills et al. (2000). Restriction enzymes *Hae*III, *Hpa*II, and *Rsa*I then digested PCR products at 37°C during 12 hours, and results were visualized on 2.5% agarose gel. Since restriction enzymes produce species-specific patterns, it was then possible to distinguish Cougar from other felid species.

Results

Baited hair traps

A total of 207 samples was collected from hair traps (Table 1). MtDNA analyses conducted on hair samples collected in 2003 revealed that two samples collected in FNP were Cougar hair. The first hair sample was found near the main road entering the park (i.e., Kinnie Brook), in a young Red Spruce (*Picea rubens*) and Balsam Fir (*Abies balsamea*) stand (6 to 12 m high, canopy closure of 70%). Ground cover mostly consisted of *Sphagnum* spp. and Bunchberry (*Cornus canadensis*). The other hair sample was found in the northern area of the park, along an old logging trail (i.e., Big Dam trail) relatively overgrown with Red Spruce, Balsam Fir and birch (*Betula* spp.). In this case, trees were taller (12-20 m) but canopy closure was only 40-50%. A 6-m-high understory composed of Balsam Fir, Red Spruce and White Birch (*Betula papyrifera*) allowed no ground cover other than birch leaves.

TABLE 1. Number of hair samples collected per location and per year for 2003-2006.

Location	Sampling periods			
	2003	2004	2005	2006
KNP	0	6	15	7
FNP	29	34	49	23
CBHNP	1	3	17	16
MIRAM	–*	–	6	1
Total	30	43	87	47

*Baited hair-traps and camera-traps were installed in the Miramichi (MIRAM) area during the fall of 2004.

FIGURE 3. Footprint found west of Blackville (GPS coordinates (NAD 1983): 20N0724671; UTM 5188486), New Brunswick, Canada (22 September 2004). Picture provided by P. Boucher. Box (to left of footprint) diameter: 8.5 cm.

Further DNA sequencing revealed that the two hair samples came from two distinct animals, i.e., a North American specimen and a South American specimen. Camera-traps were only installed in 2004, so there is no photographic record of these two individuals. No Cougar hair or picture were collected after the cameras had been installed.

Additional Observation

Sets of tracks can also be used to identify species (van Dyke and Broke 1987; Cumberland and Dempsey 1994). A footprint (Figure 3) was photographed in 2004 by three reliable observers in Blackville (southwest of Miramichi, New Brunswick) 15 minutes after they had seen the Cougar at 12:25 PM and watched it for several seconds as it was crossing a dirt road 45 m from them. This track was examined by experts and declared not to be of a Coyote (F. Scott and P. G. Crawshaw Jr., personal communication).

Discussion

Cougar detection program for the Maritimes

Hair-traps and camera-traps are alternative and convenient non-invasive methods that are cost- and time-efficient techniques for animal surveys (Carbone et al. 2001). After four years of permanent cougar monitoring in the Maritimes, the amount of field data keeps increasing. As suggested by Cardoza and Langlois (2002), it would be valuable to establish a systematic monitoring program supervised by an expert team for the Eastern Cougar population, especially for the provinces where the status of this species is indeterminate. This would allow collection of a series of undisputable physical evidence (Cardoza and Langlois 2002; Maehr et al. 2003). As mentioned by others, the probability of proving the presence of a species which has no established viable populations in a given area is almost nil (Broke and van Dyke 1985).

DNA hair analyses confirmed that two Cougars occurred in southern NB in 2003. Additional data (e.g., individual genetic haplotype) are nonetheless crucial to better understand the status of the species in this part of its range. One of the individuals detected in Fundy turned out to be a South American animal, recalling the Chilean specimen shot in Abitibi, Québec, in May 1992 (Jolicoeur et al. 2006). This may indicate that a few scattered escapees from zoos or captives released by private owners remain (Stocek 1995). However, the other positive hair sample caught in the Big Dam Trail in FNP was from an animal of North American origin. This opens up a range of possibilities. In eastern North America, estimates of the number of escaped captives kept increasing during the last 30 years. In Pennsylvania for instance, McGinnis (1996) reported only 31 cougars held in captivity in 1979, among which four or five eventually escaped. Then, less than 20 years later, according to J. Seidensticker (cited in Scott 1998*), there was an increase of 640% in the number of licensed private Cougar owners. This dramatic increase in the number of captive individuals probably suggests many more escapees of North and South American origins. Further DNA identifications will enable researchers to shed more light on this question. The fact that cougars are efficient colonizers (Nero and Wrigley 1977) with large home ranges (Seidenticker et al. 1973) ensures that the debate about the potential presence of animals in eastern Canada continues. Reported cougars may be transients, escapees or members of a remnant population, but they could act as dispersers for the (re)establishment of viable populations in eastern Canada (Scott 1998*; Maehr et al. 2002). The

determination of these cats' origin should help define the protection status they deserve.

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The Leech *Haemopis lateromaculata* (Hirudinea: Haemopidae): Its North America Distribution and Additional Notes on Species Description

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Hovingh, Peter. 2006. The leech *Haemopis lateromaculata* (Hirudinea: Haemopidae): Its North American distribution and additional notes on species description. Canadian Field-Naturalist 120(4): 443–451.

The geographic range of *Haemopis lateromaculata* Mathers 1963 (Hirudinea: Haemopidae) is extended across North America. Its distribution in the coastal region of Alaska and British Columbia suggests a coastal Pleistocene refugia separate from the populations in the lower United States and suggests that *H. lateromaculata* and the Eurasian *H. sanguisuga* Linnaeus 1758 are sister taxa. Support of the identification and geography is based on the anatomical positions of the reproductive organs in *H. lateromaculata* and *H. marmorata* Say 1824. The variations within these species are described, noting that no specific variation was confined to a geographical region.

Key Words: leech, *Haemopis laterormaculata*, description, taxonomy, distribution, North America.

In an effort to understand the limits of leech (Hirudinea) fauna distribution in western North America, a geographical study defined by hydrological basins was undertaken and is still in progress. The report herein describes a taxonomic problem with *Haemopis marmorata* (Say 1824) in western North America, a species known to be difficult to distinguish by external characteristics from *H. grandis* (Verrill 1874) (Sawyer 1972) and *H. lateromaculata*. Four populations of *Haemopis* were found without teeth and these populations were initially identified as *H. grandis* (Hovingh 1993). Examination by dissection revealed that the penis sheaths of these populations were *H. marmorata* and that these specimens had jaws. As a result of this identification problem, the penis sheaths of all mature *Haemopis* were examined.

In examining the reproductive organs of *Haemopis*, it became apparent that *H. lateromaculata* specimens in museum collections had often been misidentified as *H. marmorata*. A study of Utah (Beck 1954) and Alaskan (Moore and Meyer 1951) *Haemopis* vouchers deposited in the United States National Museum (USNM) contained several lots identified as *H. lateromaculata*. Three lots of specimens that were collected from British Columbia and Newfoundland, two of which were identified by J. Madill as *H. lateromaculata* plus one unidentified due to poor conditions are deposited in The Canadian Museum of Nature (CMN) in Ottawa, Ontario, Canada. The two lots at CMN are the first observations of *H. lateromaculata* outside of the type localities of Minnesota and Iowa (Mathers 1963). A specimen from Michigan was utilized in a leech phylogenetic studies (Borda and Siddall 2004).

The reproductive organs of *Haemopis marmorata* and *H. lateromaculata* specimens collected from western North America examined are presented in this paper. Based on accurate diagnosis of the species, the external characteristics (pigmentation patterns) were determined to distinguish these two species from one another. The results herein describe the geographical distribution of *H. lateromaculata*, and support some taxonomic and paleogeographic hypotheses concerning the family Haemopidae.

Methods

Specimens of *Haemopis* were collected during the last 20 years from localities in western North America. The surveys consisted of visual encounters and hand picking from the underside of stones, logs, and aquatic vegetation. The specimens were relaxed with 10% ethanol, blotted by paper towel to removed the mucous excreted from the relaxation process, fixed with 10% formalin in phosphate buffered saline between two sheets of paper towels overnight, and placed in 70% ethanol for preservation.

Identification of all large *Haemopis* specimens was determined by examining the reproductive organs through a mid-dorsal cut from the annulus with the female gonopore posteriorly approximately 20 annuli. If the penis sheath was not located with this examination, the dorsal cut was extended anteriorly for some 10 annuli. Teeth and jaws were examined by a mid-ventral cut of the lower lip. Posterior sucker width, pigmentation, and gonopore positions were noted. Small specimens were identified by pigmentation. Identifications followed original descriptions and taxonomic keys (Mathers 1963; Klemm 1985; Sawyer and Shelley 1976).

The facilities and specimens of the United States National Museum (USNM), Washington D.C. and the Canadian Museum of Nature (CMN), Ottawa, Ontario were utilized. The western specimens of Haemopidae in these collections were confirmed by dissection if the length was greater than 40 mm, and pigmentation patterns and the presence of teeth were examined. The eastern specimens of *Haemopis marmorata* were select-

ed by pigmentation with dissection on random samples. Specimens were also examined from water quality studies in Wyoming (Wyoming Department of Water Quality), now residing in the Albertson College of Idaho Orma J. Smith Museum of Natural History (ALBRCIDA), Boise, Idaho.

Taxonomic status

There is presently full acceptance of the haemopisine species (Davies 1991; Klemm 1985; Sawyer 1986). The higher classification of leech groupings, and leeches within the Annelida, is presently contentious, however. Historically, all the haemopisine species were placed in the genus *Haemopis* including the original description by Mathers (1954, 1963) of *H. kingi* Mathers 1954 and *H. lateromaculata.* Richardson (1969) revised the family Hirudinidae, established the family Haemopidae, and revised the genus classification by introducing the genera *Percymoorensis* including *P. terrestris* (Forbes 1890), *P. marmorata*, *P. lateromaculata*, and *P. kingi*), *Mollibdella grandis*, and *Bdellarogatis plumbeus* Moore 1912). He retained *Haemopis* for the Eurasian *H. sanguisuga* Linnaeus 1758. Richardson (1971) suggested that *Percymoorensis* and *Haemopis* (the Eurasian species) were associated in the subfamily Haemopinae, and that *Mollibdella* and *Bdellarogatis* were in the subfamily Mollibdellinae; he also identified a Mexican species *Percymoorensis caballeroi* Richardson 1971 in that paper.

Davies (1991); Davies and Govedich (2001); and Soós (1969) accepted the generic nomenclature of Richardson (1969) but retained the earlier familial classification of Hirudinidae. Soós (1969) expressed reservation about Richardson's classification of Hirudinidae (including Haemopidae) based on his use of type-specimens, and that "long standing genera are strongly heterogeneous in content and cannot any longer be separated one from the other entirely by single factors, or contained within single divisions in the key". Klemm (1995), Manoleli et al. (1998), and Sawyer (1986) rejected the generic nomenclatural changes of Richardson but accepted the family Haemopidae classification.

A new species, *Haemopis septagon* Sawyer and Shelley 1976, was described from specimens collected from North Carolina in eastern United States. In their description Sawyer and Shelley noted that if the classification of Richardson (1969) was accepted, *H. septagon* warranted placement in a new genus. Davies (1991) placed this species with the genus *Percymoorensis*. The uncertainty of Richardson's classification with respect to *H. kingi* and *H. lateromaculata* was revealed when Richardson (1969, 1971) stated that these two species most likely belong to a new genus. He did not examine either species but relied on Mathers (1954, 1963) for his paper (Richardson 1969). Borda and Siddall (2004) examined six species of *Haemopis* for phylogenetic studies involving anatomical characteristics, 12 S mitochondrial rDNA, 18S and 28S nuclear rDNA, and cytochrome c oxidase subunit I gene fragments. Of the 24 anatomical criteria that were utilized, 23 were common to all six species, thus not significant in determining genera or species relations. Borda and Siddall (2004) confirmed the family Haemopidae. I maintain use of the genus *Haemopis* and the family Haemopidae until additional and more conclusive phylogenetic studies have been reported for all the hemopisine species, using population samples representing the entire range of these widespread species.

Results

Distribution of *Haemopis lateromaculata* in North America

The Nearctic distribution of *Haemopis lateromaculata* is shown in Figure 1 and listed in Table 1. This distribution is based on museum specimens (USNM, ALBRCIDA, and CMN), from my (PH) collections from the geographical studies in western North America and from water quality studies in Wyoming (ALBRCIDA). Anatomical dissections distinguished *H. lateromaculata* from *H. marmorata* in western North America when the plain ventrum and plain, cream, or yellow colored lateral margins were prominent, and thus could be used to distinguish these two congeners from one another. Based on this pigmentation distinction, juvenile specimens (< 40 mm) and museum specimens in eastern North America *H. marmorata*, were examined and those with no ventral pigmentation were considered *H. lateromaculata.* Some specimens without pigmentation were dissected and the species determined. The following are the locations of *Haemopis lateromaculata* (underlined accession numbers refer to museum specimens catalogued as *H. marmorata* or as *Haemopis*). Most of these misidentified specimens had been catalogued and accessioned into the museum collections before the work of Mathers (1963) had been completed and published.

Alaska: USNM *19230* Yes Bay, *20732* Afognak Island, *21255* Yes Bay, *21256* Sanak Island, *43455* Revillagigedo Island, CMNA *1982-0746* Esther Island, and PH collections from Susitna River drainage, Kenai Peninsula, and Kodiak Island.

Western Canada: Yukon Territory: PH collection from Pelly River drainage (Yukon River drainage); British Columbia: USNM *19231* North Fork Moose River (at least two Moose Rivers occur in British Columbia), and USNM *38352* "D" [Dee] Lake; CMNA *1985-0289* and CMNA *1990-0056* (identified by J. Madill, but was not found in the collection) Fraser River drainage; and from PH collections from the Fraser River drainage (CMNA *2006-0036*) and Haida Gwaii (Queen Charlotte Islands) (CMNA *2006-0037*); Alberta: CMNA *1978-0426* Mackenzie River drainage; and from PH collection Peace River drainage (Mackenzie River drainage) (CMNA *2006-0034*).

Lower western United States: Idaho: from PH collection in the Snake River drainage (Columbia River

FIGURE 1. The distribution of *Haemopis lateromaculata* in North America. Locations are shown by (a) squares, museum specimens (NMNH, CMN); (b) circles, western North America survey sites (preliminary results) and identifications from Wyoming water quality studies; and (C) diamonds, Mathers (1963) locations.

drainage); Oregon: from PH collection in the Klamath River drainage and the Great Basin; Wyoming: from PH collection in the Snake River drainage (Columbia River drainage) and Water Quality Studies in Missouri River drainage (ALBRCIDA *61050-61052*); California: from PH collection in the Pit River drainage (Sacramento River drainage); Nevada: from PH collection in the Great Basin; Utah: USNM *38308*, *39056*, USNM *38624*, *38627* (the latter two identified to genus), and from PH collection in the Great Basin and Colorado River drainage; Colorado: from PH collection in the South Platte River drainage (Missouri River drainage); New Mexico: USNM *50192* Rio Grande drainage (did not dissect) .

Eastern North America: Canada: Saskatchewan: USNM *38353*; Manitoba: USNM *38347*, CMN *1985-0292*, *1985-0301*; Ontario: USNM *38360*, *38348*, CMN *1985-0253*, *1985-259*, *1985-279*, *1987-0670*, *1988-0036*, *1988-0163*; Newfoundland: CMN *1982-0654*, *1985-0378* (both identified by J. Madill); lower United States: Michigan: USNM *38331*; Missouri: USNM *20681*; District of Columbia: USNM *30223*; Virginia: USNM *42650*.

TABLE 1. Distribution of *Haemopis lateromaculata* in North America, from the field collections in western North America and from the Orma J. Smith Museum of Natural History (ALBRICIDA), Canadian Museum of Nature (CMNA), and the United States Museum of Natural History (USNM). (1) In poor condition or not found in the collection. (2) At least two Moose Rivers in British Columbia. (3) *Haemopis* unidentified. PH, Peter Hovingh collection work in progress.

Province or State	Catalogue	Date	Locator
Alberta	CMNA 1978-0426	1907	Beaver Lake
Alberta	CMNA 2006-0034	2000	Slave River drainage
British Columbia	CMNA 1985-0289	1976	150 Mile House
British Columbia	CMNA 1990-0056	1989	Cariboo District
British Columbia	CMNA 2006-0036	1988	Chilcotin River drainage(1)
British Columbia	CMNA 2006-0037	2000	Haida Gwaii
British Columbia	USNM 19231	1911	North Fork Moose River (2)
British Columbia	USNM 38352	1935	[Dee] "D" Lake
Manitoba	CMNA 1985-0301	1970	Vita
Manitoba	CMNA 1985-0292	1976	LaSalle River
Manitoba	USNM 38347	1927	
Newfoundland	CMNA 1982-0654	1981	Placenta Bay
Newfoundland	CMNA 1985-0378	1985	St Marys Bay
Ontario	CMNA 1985-0259	1920	Abitibi River
Ontario	CMNA 1985-0262	1920	Missinaibi River
Ontario	CMNA 1985-0253	1922	Ottawa River
Ontario	CMNA 1985-0279	1965	Albany River
Ontario	CMNA 1988-0036	1987	Thunder Bay
Ontario	CMNA 1988-0163	1987	Rainy River
Ontario	CMNA 1987-0670	1987	Kenora
Ontario	USNM 38348	1925	Lake Abitibi
Ontario	USNM 38360	1931	Lake Nipissing
Saskatchewan	USNM 38353	1940	Waskasov
Yukon Territory	CMNA 2006-0035	2000	Pelly River drainage
Alaska	CMNA1982-0746	1961	Esther Island
Alaska	CMNA 1985-0297	1961	Hinchinbrook Island (3)
Alaska	CMNA 1978-0360	1961	Chuckagof Island (3)
Alaska	USNM 19230	1905	Lake Mc Donald, Yes Bay
Alaska	USNM 21225	1907	Lake Mc Donald, Yes Bay
Alaska	USNM 20732	1938	Afognak Island
Alaska	USNM 21256	1937	Sanak Island
Alaska	USNM 43455	1897	Revillagigedo Island
Alaska	PH 1671-1677	2003	Kodiak Island
Alaska	PH 1660	1994	Cook Inlet
Alaska	PH 1661-1664	2003	Cook Inlet
Alaska	PH 1667, 1669	1994	Kenai Peninsula
Alaska	PH 1665, 1666	2003	Kenai Peninsula
Alaska	PH 1668, 1669	2003	Kenai Peninsula
Alaska	PH 2029	2006	Cold Bay, Alaska Peninsula
California	PH (0000)		Pit River
Colorado	PH (0000)	2002	Great Plains
District of Columbia	USNM 30223	1911	Easter Branch
Idaho	PH (0000)	1994	Snake River drainage
Michigan	USNM 38331	1925	Mecosta County
Missouri	USNM 20681	1935	Sikeston
Nevada	USNM (PH 848)	1989	Ruby Marsh
New Mexico	USNM 50192	1929	Pecos River
Oregon	USNM (PH 852)	1996	Catlow Valley
Oregon	PH (0000)	1995	Klamath Lake
Utah	USNM 38308	1952	Provo
Utah	USNM 38624	1952	
Utah	USNM 38627	1952	Mapleton
Utah	USNM 39056	1952	Provo
Utah	USNM (PH 497)	1990	Provo River
Utah	USNM (PH 498)	1995	Provo River
Utah	USNM (PH 499)	1989	Provo River
Utah	USNM (PH 489)	1989	Sevier River
Utah	USNM (PH 491)	1995	Sevier River
Utah	USNM (PH 487)	1990	Weber River
Utah	USNM (PH 488)	1994	Weber River
Utah	USNM (PH 486)	1993	Bear River

TABLE 1. *continued*

Province or State	Catalogue	Date	Locator
Virginia	USNM 42650	1957	Dismal Swamp
Wyoming	PH (0000)	1991	Snake River drainage
Wyoming	ALBRICIDA 61050	1994	Johnson County
Wyoming	ALBRICIDA 61051	1997	Crook County
Wyoming	ALBRICIDA 61052	1997	Niobrara County

Identification of leech specimens: external characteristics

TEETH. All of the *Haemopis lateromaculata* contained teeth (denticles). This characteristic would separate these specimens from *H. plumbea* and *H. grandis.* Four populations (Utah, Nevada, Wyoming, Montana) of *H. marmorata* were without teeth. One population (Utah) was collected in 1941 (USNM *50195*) and again in 1986 suggesting that the loss of denticles may be due to environmental or genetic factors resulting from colonization after the dessication of Lake Bonneville after 13 000 years ago.

POSTERIOR SUCKER. Although the posterior sucker is large (about ¾ the width of the body) in *Haemopis lateromaculata* and small (less than ½ the width of the body) in *H. marmorata* (Klemm 1985), the state of body relaxation was highly variable. This variability made the relative size of the posterior sucker to body width rather arbitrary.

PIGMENTATION. The dorsal surface of *Haemopis lateromaculata* was patterned with darker blotches or mottled, or large to small speckles, of frequent to rare numbers. The lateral margins were cream or yellow (shared with *H. terrestris*) and interrupted with irregular dark intrusions dorsally (a very diagnostic character), visible from both the dorsal and ventral surface [specimens from 14 sites: the Great Basin (8), Colorado River drainage (2), Great Plains (1), Columbia River drainage (2), and the Yukon River drainage (1)]; or with the lateral margins the same shade as the ventrum, without cream or yellow coloring [specimens from 21 sites: the Great Basin (2), Pacific Coast drainages (2), Fraser River drainage (1), Mackenzie River drainage (1), coastal islands and their adjacent shores of British Columbia and Alaska (17)]. The external characteristic that identified all of the specimens was the plain ventral surface. Mathers (1963: page 170) noted "with a few indistinct black and yellow blotches" on the ventral surface. I observed one specimen with an occasional speckle on the ventral surface.

The pigmentation of *H. marmorata* in western North America ranged from heavily blotched or mottled to heavily speckled or lightly speckled on both the dorsum and ventrum (61 sites), with the ventrum having subdued pigmentation of the same pattern. If either *H. lateromaculata* or *H. marmorata* were of the light- and/or dark-colored immaculate phase (Klemm 1985: page 155), pigmentation could not be used to identify these two species. The light-colored immaculate phase was not found in the living state in western North America, but only in preserved specimens in museums. The lack of a dorsal stripe excluded *H. terrestris*, *H. kingi*, and *H. septagon* from further consideration in this study.

MAXIMUM LENGTH (MM). *Haemopis lateromaculata*: Great Basin (90), Colorado River drainage (67), Columbia River drainagae (31), Mackenzie River drainage (83), Fraser River drainage (30), Queen Charlotte Islands (81), Yukon River drainage (82), Alaska (112), and Great Plains (50). *Haemopis marmorata*: Great Basin (112), Colorado River drainage (95), Columbia River drainage (121), Pacific Coast drainages (98), Fraser River drainage (98), and Great Plains (94). Length is highly variable, dependent upon both the age of living specimens and their state of relaxation during fixation.

GONOPORE POSITIONS. *Haemopis lateromaculata*: Male gonopore XI *b6* anterior ½; female gonopore XII *b6* anterior ½, as determined on two specimens with developed clitellum from Nevada and Yukon Territory. All gonopore positions were separated by 5 annuli and occurred on the anterior ½ of the annulus. *Haemopis marmorata*: Male gonopore XI *b*6 anterior ½; female gonopore XII *b*6 anterior ½, as determined on three specimens with developed clitellum from Nevada and Colorado. Most gonopore positions were separated by 5 annuli and occurred on the anterior ½ of the annulus. Three exceptions: male XI *b*6 mid-annulus and female XII *b6* mid-annulus, and male XI *b*6 mid-annulus and female XII *b*5 posterior ½ both from Arizona; and male and female on mid-annulus from British Columbia. Sawyer (1972) noted additional variations of the gonopores from mid-annulus to the furrow. The male and female gonopore separations excluded *H. septagon* from further consideration during this study.

Identification of leech specimens by reproductive organs

Figure 2 illustrates the mean measurements of the reproductive organ position and Table 2 lists the mean ± standard deviation. The posterior position of the left and right ejaculatory bulbs, the posterior position of the penis sheath loop and the vagina organs, and the anterior position of the prostate organ (anterior end of male atrium) were selected for their defined shape, largely attributed to the muscular nature of the organs (Richardson 1969). The organ positions were determined by vertical positioning of the organ with the annulus, and hence counting the number of annuli to the annulus with the female gonopore. There is a possible error of annuli count of ±1 annulus due to the positioning in individual specimens. The nomenclature of the organs follows that of Klemm (1985). Left and right positions are determined from the dorsal side. Comparison to

other species is based on literature (Klemm 1985; Mann 1954; Richardson 1971).

PENIS SHEATH LOOP. *Haemopis lateromaculata*: The penis sheath loop was located at annulus XIII *b5* (XII *b6* to XIV *a2*). The penis sheath was generally U-shaped and distinguished *H. lateromaculata* from *H. marmorata*, *H. plumbea*, *H. terrestris*, *H. septagon*, and *H. caballeroi*. *Haemopis marmorata*: The penis sheath loop was located at annulus XVII *b1* (XV*b1* to XVIII *b5*), a range comparable to Sawyer (1972). The penis sheath was generally J-shaped and on the left side. The ranges did not overlap between *H. lateromaculata* and *H. marmorata*. The average length of the penis sheath of *H. lateromaculata* was 21 annuli and of *H. marmorata* 38 annuli between the male gonopore and the prostate gland. Abnormal variations for the penis sheath of *H. lateromaculata* include position on the right side (4 specimens from Yukon Territory, Alaska, and Colorado) and highly contorted (1 specimen from Alaska). Abnormal variations for the penis sheath of *H. marmorata* include: positioned on the right side (11 specimens from Great Basin, Colorado River Basin, and Great Plains), and highly contorted (6 specimens from Great Basin, Great Plains) with one specimen in which the terminal loop turns medially and is twisted to form a topless "8".

PROSTATE GLAND. *Haemopis lateromaculata*: The anterior end of the male atrium is covered by the prostate gland and was located at annulus XI *a2* (X *a2* to XII *b6*), positions that are anterior to the female gonopore and for the most part anterior to the male gonopore. These locations are associated with the U-shaped penis sheath. *Haemopis marmorata*: The anterior end of the prostate gland was located at annulus XIV *b5* (XIII *b1* to XVI *b5*), defining the J-shaped penis sheath.

EJACULATORY BULBS. *Haemopis lateromaculata*: The posterior end of the left ejaculatory bulb (seminal vesicle) was located at annulus XIII *b2* (XII *b2* to XIV *a2*) whereas the posterior end of the right ejaculatory bulb was at annulus XIII *b1* (XII *b1* to XIV *a2*). Although the locations show left-right symmetry (Figure 2), large variations were found in which the left bulb was 10 annuli posterior to 7 annuli anterior of the right bulb. The distribution of the positions of the ejaculatory bulbs was: right anterior to the left, 13 specimens; right even with the left, 13 specimens; and right posterior to the left, 8 specimens). *Haemopis marmorata*: The posterior end of the left ejaculatory bulb was located at XIV *b2* (XIII *b1* to XV *b5*) whereas the posterior end of the right ejaculatory bulb was at annulus XIV *b1* (XII *a2* to XV *b6*). The left bulb ranged from 9 annuli posterior to 5 annuli anterior of the right bulb. The distribution of the ejaculatory bulbs was: right anterior to the left, 19 specimens; right even with the left, 16 specimens; and right posterior to the left, 17 specimens), a pattern noted by Sawyer (1972). Two specimens had only one ejaculatory bulb.

VAGINA. *Haemopis lateromaculata*: The posterior end of the vagina (vaginal bulb) was found at XIV *b6* (XIII *a2* to XVII *a2*). The vagina was always posterior to the posterior reach of the penis sheath loop and was generally in the median region. *Haemopis marmorata*: the posterior end of the vagina was found at XVI *b1* (XIV *b2* to XVII *a2*), comparable to the findings of Sawyer (1972). The vagina was always anterior to the posterior reach of the penis sheath loop and posterior to the anterior end of the prostate gland, and generally located in the medial region. Three specimens had the vagina location anterior to the anterior end of the prostate gland. The position of the vagina of *H. caballeroi* had a relative position to the penis sheath loop and the prostate gland (atrium) as in *H. marmorata*, but the two specimens of *H. caballeroi* were highly contracted and hence not typical (Richardson 1971). The extensive penis sheath and its relation to the vagina suggests that these two species deserve a separate genus — in

TABLE 2. Annuli location of selected reproductive organs in *Haemopis marmorata* and *H. lateromaculata*. Annulus X *b1* was number 1 and annuli posterior to this annulus were sequentially numbered. Organ nomenclature was taken from Klemm (1985). Figure 2 illustrates the organs and the points of measurement.

	H. lateromaculata N = 31	*H. marmorata* N = 55
Penis sheath loop		
Mean ± standard deviation	18.8 ± 2.6	35.8 ± 4.6
Range	14 – 23	25 – 44
Anterior prostate gland		
Mean ± standard deviation	7.2 ± 2.5	23.9 ± 3.7
Range	2 – 14	16 – 35
Posterior left ejaculatory bulb		
Mean ± standard deviation	16.7 ± 3.0	21.3 ± 3.4
Range	11 – 23	15 – 29
Posterior right ejaculatory bulb		
Mean ± standard deviation	15.5 ± 3.1	21.0 ± 3.4
Range	10 – 23	12 – 30
Posterior vagina		
Mean ± standard deviation	24.6 ± 4.7	30.5 ± 3.7
Range	17 – 38	21 – 38

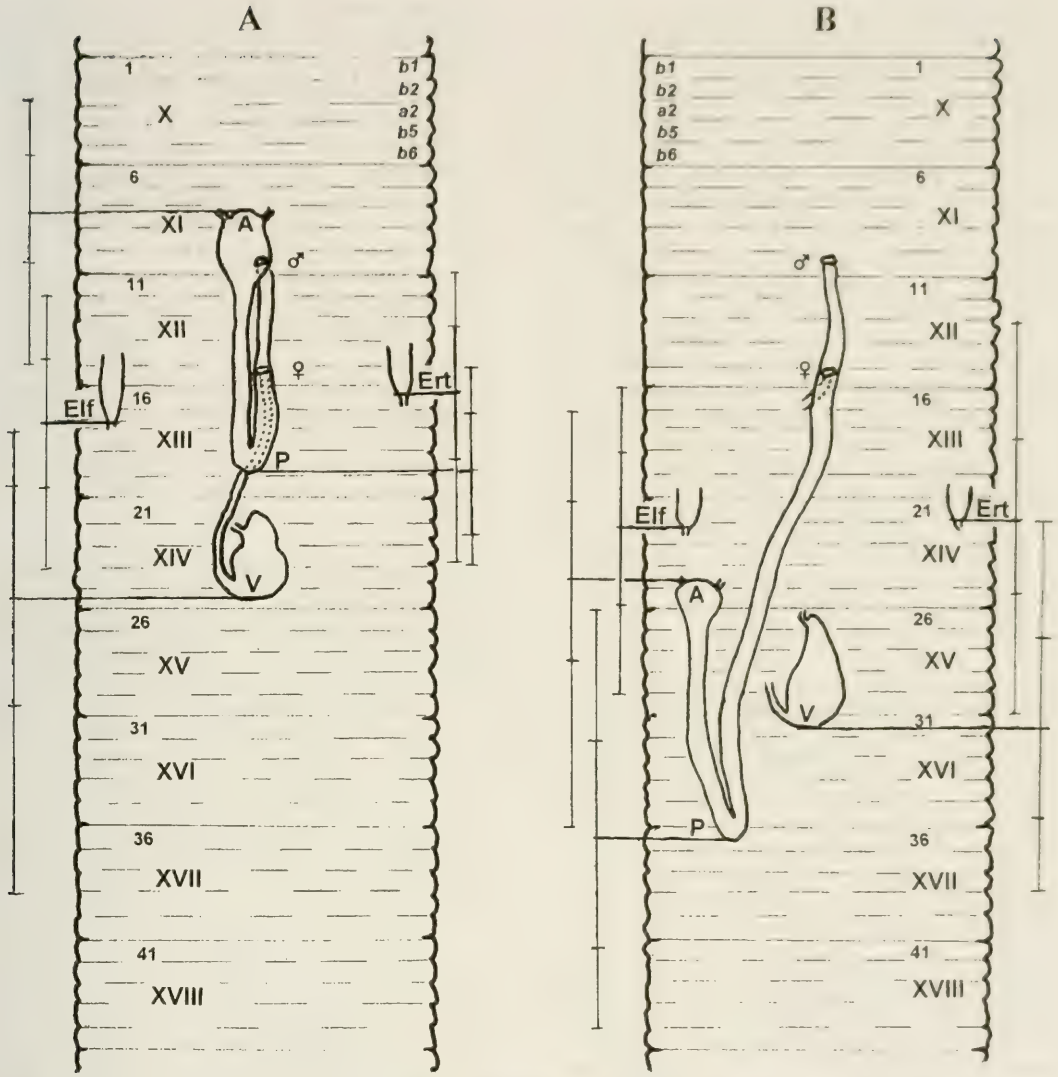

FIGURE 2. Measured reproductive organs in *Haemopis lateromaculata* (A) and *H. marmorata* (B), viewed from the dorsum. The segments are shown in Roman numerals starting with segment X and extend to segment XVIII. Each segment has five annuli as denotated names shown on the right side of segment X. For the purposes of this paper, the first annulus is numbered 1 and is sequenced posteriorly as noted on the left side with only the first annulus of each segment numbered (see Table 2). Male gonopore on IX *b6* and female gonopore on XII *b6*. Denotations: Elf, posterior reach of the left ejaculatory bulb; Ert, posterior reach of the right ejaculatory bulb; P, posterior reach of the penis sheath loop; V, posterior reach of the vagina; and A, the prostate gland at the anterior end of the male atrium. The vertical lines represent one standard deviation (thick lines) and total range (thin lines) (see Table 2).

this case *Percymoorensis*, if one follows the distinct genera classification in Erpobdellidae of *Nephelopsis*, *Mooreobdella*, and *Erpobdella*, each having morphological distinct male atriums and sperm ducts.

Discussion

Haemopis lateromaculata is now considered to be widely distributed throughout North America; prior to this study, its known distribution had been limited to two states (Figure 1). The presence of this leech on the Alaskan Peninsula and adjacent islands, the Cook Inlet region, the Alexander Archipelago of southeast Alaska, and Haida Gwaii (Queen Charlotte Islands) of British Columbia suggest that these leeches occupied off-shore coastal refugia during the Pleistocene and were separated from those populations south of Canada's cordil-

leran and continental glaciers. These northwest refugia were limited by extensive glaciers from Haida Gwaii to Umnak Islands (Coulter et al. 1965; Clague 1989; Kaufman and Manley 2004) with coastal cordilleran glaciers occurring to 12 000 years ago (Peltier 1994; Dyke 2004; Fulton et al. 2004). While the occurrence of small terrestrial refugia have been postulated from Kodiak to the Queen Charlotte Islands (Heusser 1989; Ramsey et al. 2004), present day freshwater habitats (ponds, lakes, slow moving and meandering streams) from which leeches have been collected add a new dimension to the terrestrial refugia.

The Pleistocene-Holocene environments were changing due to eustasy (the sea level rising at least 120 m) and glacio-isostatic surface adjustments involving the advance and recession of the glaciers. Hetherington et al. (2003, 2004) mapped this environment for the Haida Gwaii and described a land bridge between the islands and the British Columbia mainland that existed between 11 700 and 11 200 years ago as a result of the presence of a forebulge from the retreating cordilleran glacier. This process, if applied throughout the glaciated region of coastal Alaska, may have allowed island by island transfer of leeches from coastal Pleistocene refugia, thus accounting for the modern day presence of *H. lateromaculata* populations on the coastal northwestern North America mainland (Reimchen and Byun 2005). Upstream movement of *H. marmorata* has been noted (Herrmann 1970; Richardson 1942; Sawyer 1970), and active movement (to Prince Edward Island) must have occurred by direct means, and not as passive movement by birds or other agents (Richardson 1943). It is assumed herein the cordilleran glaciers and marine habitats prevented any leeches from continental populations colonizing the coastal habitats.

Lukin (1976) suggested that *Haemopis* originated in the Nearctic and penetrated the Palaearctic from the northeast [Siberia] when northern Asia had a warmer climate. He further suggested that *H. sanguisuga* emerged at that time and is now found across central Eurasia to the Amur Basin and near Vladivostok in eastern Asia, but not in Kamchatka Peninsula. The center of biodiversity of *Haemopis* is in eastern North America, supporting Lukin's postulate. Only two species (*H. lateromaculata* and *H. marmorata*) moved out of this region to occupy most of North America, and only *H. lateromaculata* has been identified in Alaska and the coastal islands, suggesting range expansion in an earlier epoch before the range expansion of *H. marmorata.* From the Late Cretaceous (80 million years ago) to the middle Pliocene (3 million years ago), North America and eastern Asia were connected between Alaska and eastern Siberia (Repenning and Brouwers 1992; Smith et al. 1994). For much of this time, the climate in this region was comparable to that of the southeastern United States today (Bassinger 1991).

I propose that *H. lateromaculata* and *H. sanguisuga* are sister species. Two anatomical features of *H. lateromaculata* and *H. sanguisuga* support this relationship: (1) the vaginal bulb lies posterior to the penis sheath loop (shared with *H. grandis* and *H. kingi*) and (2) the prostate gland (anterior end of the male atrium) occurs mostly anterior to the male gonopore (shared with *H. kingi* and *H. caeca*) (Mann 1954; Klemm 1985; Manoleli et al. 1998). Note that *H. kingi* occurs in both groups, a confirmation of Richardson's (1969, 1971) views that *H. kingi* and *H. lateromaculata* are closely related.

The distribution of a species is as important as the original description of a species. As noted by Newton (2003: page 90) with respect to birds, "how species are formed is central to understanding their distributions" and "genealogy and distribution are not separate issues: they are simply different sides of the same biological coin". This paper contributes to the definition of *H. lateromaculata* by the addition of geographical limits of its distribution and its evolutionary implications.

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Predation on Artificial Nests of Northern Bobwhites, *Colinus virginianus*, by Mammalian Mesopredators: Does the Problem-Individual Paradigm Fit?

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Using mark/recapture procedures, predation on artificial nests of Northern Bobwhites (*Colinus virginianus*) by mammalian mesopredators (Raccoons, *Procyon lotor*; Virginia Opossums, *Didelphis virginiana*; and Striped Skunks, *Mephitis mephitis*) was assessed in relation to the "problem-individual" paradigm. The paradigm, which is untested among mammalian mesopredators, predicts that most predation on a prey species is by a small number of individuals repeatedly involved. By examining number of captures and recaptures on artificial nests during non-nesting and nesting periods in 2000-2003, predation within and among species were gauged. Results varied by species, sampling period, and year; however, predation was by a small percentage of individuals and only within the population of Striped Skunks were individuals (2 of 49) captured on an artificial nest more than once. Raccoons, Virginia Opossums, and Striped Skunks were responsible for 10, 2, and 12% of the loss of all nests available to predators, respectively. Based on low occurrences of individuals repeatedly involved in predation on nests, the problem-individual paradigm was unsubstantiated. Although Raccoons, Virginia Opossums, and Striped Skunks (as individual predators) had only moderate impact on the population of Northern Bobwhites, they had a much greater impact collectively (preying upon 24% of all nests available). To maximize Northern Bobwhite success, the most productive management is probably best directed toward a vertebrate guild that includes mammalian, avian, and reptilian predators, and management strategies that use multiple techniques.

Key Words: Raccoons, *Procyon lotor*, Striped Skunks, *Mephitis mephitis*, Virginia Opossums, *Didelphis virginiana*, Northern Bobwhites, *Colinus virginianus*, artificial nests, problem individuals, predation, Tennessee.

Due to several factors (e.g., release of predators and reduced hunting; Young and Ruff 1982; Amarasekare 1993; Mosillo et al. 1999), populations of Raccoons (*Procyon lotor*), Virginia Opossums (*Didelphis virginiana*), and Striped Skunks (*Mephitis mephitis*) have increased in abundance throughout much of their range. These increases have caused widespread removal to be attempted as one means of controlling populations of these species (United States Department of Agriculture 2004*). Linnell et al. (1999), in discussing carnivore-livestock conflicts, pointed out that individuals or demographic groups within a predator population can show different behavioral traits where only a small proportion of individuals is accountable for taking significant numbers of a prey species. They refer to the phenomena as the "problem-individual" paradigm. Although this paradigm appears to fit some larger carnivores (Rabinowitz 1986; Ross et al. 1997; Sacks et al. 1999; Stahl et al. 2001), the hypothesis rarely has been tested (Linnell et al. 1999). Presently, the existence of individuals or a demographic group within mid-sized mammalian predators that prey upon a disproportionate number of nests of ground-nesting birds is unknown. Different rates of predation, by individuals or species, could allow for targeted removal of individuals rather than widespread removal as a means of controlling nest predation which may have broad conservation and management application as fewer individual predators would need to be removed.

Mammalian mesopredators are among the known predators of Northern Bobwhites (*Colinus virginianus*; Leimgruber et al. 1994; Fenske-Crawford and Nieme 1997), and populations of this game bird have declined throughout most of its range (Brennan 1991). However, causes of mortality for Northern Bobwhites are not well understood (Burger et al. 1995), and rates of predation within and among species of mammalian predators on Northern Bobwhites are uncertain. Additionally, mid-sized mammalian predators have been successfully captured and recaptured in live traps (Johnson 1970; Baldwin et al. 2004) and have been shown to prey upon artificial nests of Northern Bobwhites (Leimgruber et al. 1994; Fenske-Crawford and Niemi 1997); therefore, they make a good model for assessing the "problem-individual" paradigm using capture/recapture procedures.

The purpose of the present study was to examine the "problem-individual" paradigm in light of predation by populations of mammalian mesopredators on artificial nests of Northern Bobwhites. Specifically, the prediction was tested that predation on artificial nests of Northern Bobwhites by Raccoons, Virginia Opossums,

and Striped Skunks is not widespread within and among species. This work should assist in developing sound conservation and management programs for Northern Bobwhites and control of mammalian mesopredators.

Methods

This investigation was conducted on the Ames Plantation (Ames; 35°4'N, 89°13'W), an agricultural experiment station of The University of Tennessee and home to the National Field Trial Championship for bird dogs, located in Hardeman and Fayette counties, Tennessee. Ames was approximately 7500 ha and consisted of a mosaic of habitat types that included agricultural fields, pastures, upland hardwoods, bottomland hardwoods, and pine plantations. On the site, about 2000 ha were managed extensively for Northern Bobwhites. The site provided sufficient bird populations (autumn densities of ca. 2-3 birds/ha; Seckinger 2004) and associated predator suite (Leberg and Kennedy 1988; Baldwin 2003; Baldwin et al. 2004) to allow study of a ground nesting bird. For a more detailed description of Ames see Baldwin et al. (2004).

Two study sites (separated by 1.6 km) were sampled. Each was 1.6 km^2 and was similar in habitat (fragmented, upland hardwood forest interspersed with early successional fields). Because results obtained at each site were similar, results are combined and are presented here. Trapping during the non-nesting season (October-December 2000-2002) was conducted using Raccoon-size live traps (81.3 × 25.4 × 30.5 cm; Tomahawk Live Trap Co., Tomahawk, Wisconsin, or Havahart Live Traps, Woodstream Corporation, Lititz, Pennsylvania), which were baited with cat food and placed in an 8 × 8 configuration with traps spaced at about 230-m intervals. Sampling was conducted for 32 nights/season (for a total of 2000 trap nights/season). Once captured, sex and age were determined, and individuals were tagged (National Band and Tag Company, Newport, Kentucky) in both ears. Additionally, to confirm that individuals remained on the study site during the nesting season, 17, 3, and 3 Raccoons; 10, 9, and 5 Virginia Opossums; and 7, 8, and 1 Striped Skunks were fitted with radiocollars in 2000, 2001, and 2002, respectively. Animals were verified as being on the study site using a three-element hand-held antenna and a portable receiver. Telemetry equipment was from Advanced Telemetry Systems, Inc., Isanti, Minnesota. All individuals were released at the site of capture. Work during this period provided a known number of marked individuals that could be compared to those individuals captured during the nesting trapping season.

Results obtained during the nesting trapping season (June-September 2001-2003) were derived using artificial nests (10 cm wide by 6 cm deep) and baited with two eggs of Northern Bobwhites (Hernandez et al. 2001). The nest itself, constructed from wicker, was commercially purchased. Before placement, nests were left outdoors in an undisturbed state for 5-7 days to minimize human odors as suggested by Donalty and Henke (2001). Predators can cue on human odors at artificial nests (Whelan et al. 1994), but this can be minimized by rain or scents (Donalty and Henke 2001). To address this concern, eggs were rinsed with distilled water and handled with rubber gloves when placed on nests (Small and Hunter 1988). By comparing individuals of the known population (non-nesting season captures) that also were captured on artificial nests during the nesting season, the percentage of the population actively involved in predation on artificial nests was determined.

Artificial nests were placed inside live traps. At each site, 80 traps were established; 50 were in actual use at any one time. Traps were placed either selectively or randomly which resulted in an irregular distribution over each of the 1.6 km^2 study areas. Because of this placement of traps, artificial nests occurred in a variety of habitat types which can be typical of Northern Bobwhites (Stribling 1996). Traps that were without nests were wired open. All traps were camouflaged with available vegetation. Once a nest was preyed upon, another trap (randomly or selectively placed) in another location had an artificial nest placed inside. Traps with a preyed-upon nest were closed and no longer used. This provided 50 nests on each of the two sites to be in continuous use. Traps in operation were open for 90 nights/season (for a total of 9000 trap nights/season), and were checked daily. To minimize animals associating traps with nests, 25 pseudo-nests were established on each site. These were made of chicken wire in the shape and size of the actual traps used to contain artificial nests. Pseudo-nests were not baited and were randomly placed in the study areas.

Results

For comparisons between nesting and non-nesting seasons, radiotelemetry procedures confirmed that 9 Raccoons, 1 Virginia Opossum, and 2 Striped Skunks, which were radiocollared during the non-nesting season (2000), were present during the nesting-trapping season (2001). Three Raccoons collared in the non-nesting sessions (2000) along with 1 Striped Skunk were present on the study area for the nesting-trapping session (2002). There also was one Raccoon and one Striped Skunk collared during the non-nesting-trapping session (2002) present on the study area for the nesting-trapping session (2003).

Capture data derived from the two sampling periods varied somewhat by species, year, and sampling period (Table 1). Sampling during the non-nesting period revealed the presence of all target species, with the greatest number of individuals varying by species each year. Sampling during the nesting period also showed presence of all targeted species during each year but in smaller numbers and with less variation in data across years than observed in the non-nesting period.

TABLE 1. Capture data derived in a study of predation by mammalian mesopredators (Raccoons, Virginia Opossums, Striped Skunks) on artificial nests of Northern Bobwhites during two trapping sessions (non-nesting, nesting) on the Ames Plantation in western Tennessee 2001-2003. C = number of individuals captured; R = number of individuals recaptured at least one time during the same trapping session of the same year; %R = percentage of marked individuals recaptured (R/C × 100); M = number of individuals captured > 2 times; %COL = the percentage of radio-collared animals captured (number of collared animals recaptured/total number collared × 100%); T = number of individuals captured during the non-nesting period that were recaptured during the nesting period; %K = percentage of individuals captured during the non-nesting period that were recaptured during the nesting period (T/C of the Non-nesting period × 100%).

		Non-nesting (October–December)					Nesting (June–September)					Captured during both seasons	
Year	Species	C	R	%R	M	%COL	C	R	%R	M	%COL	T	%K
2001	Raccoon	41	24	59	6	18	13	0	0	0	11	4	10
	Virginia Opossum	33	13	39	8	10	3	0	0	0	0	0	0
	Striped Skunk	12	5	42	4	43	22	1[1]	5	1[1]	0	1	8
2002	Raccoon	19	8	42	1	0	14	0	0	0	33	0	0
	Virginia Opossum	19	9	47	6	0	3	0	0	0	0	0	0
	Striped Skunk	24	12	50	7	0	11	1	9	0	0	1	4
2003	Raccoon	38	17	45	4	0	16	0	0	0	0	3	8
	Virginia Opossum	89	24	27	9	20	4	0	0	0	0	1	1
	Striped Skunk	46	18	39	8	0	16	0	0	0	0	0	0

[1] This reflects predation by the same individual.

The total number of nests available to predators was 433. Raccoons were responsible for 43 nests preyed upon (10% of all nests available to predators). Virginia Opossums were responsible for predation on 10 nests (2%), and Striped Skunks destroyed 52 nests (12% of all nests available). Collectively, these predators preyed upon 24% of all available nests. No significant pattern existed in the age or sex of the predators involved in predation on artificial nests.

Discussion

Results of this study documented that at most only 10% of a known predator population (Table 1) was actively involved in predation on artificial nests of Northern Bobwhites. Additionally, individual predator species were involved in predation on artificial nests to varying levels (Table 1). Based on these results, the prediction that predation on artificial nests of Northern Bobwhites by Raccoons, Virginia Opossums, and Striped Skunks is not widespread within and among species, is supported, and the "problem-individual" paradigm is unsubstantiated. All predators assessed had members captured multiple times during the non-nesting season. These results were similar to those reported in other studies of mesopredators conducted during autumn and winter (non-nesting seasons) in the region (Ladine 1995; Baldwin 2003). Such results demonstrate that individuals can be captured and recaptured in suitable numbers to explore the "problem-individual" paradigm. However, only two Striped Skunks were captured on artificial nests more than once. Given that these individuals represented only 2 of 49 Striped Skunks captured and were only captured 2 and 3 times, respectively, in the present study and that Vickery et al. (1992) reported predation by Striped Skunks on nests of birds was not targeted, these results do not corroborate the "problem-individual" paradigm. Additionally, in comparison with larger mammalian predators, this paradigm has been associated, generally, with much higher levels of predation and by greater numbers of individuals repeatedly involved in taking prey (Claar et al. 1986; Stander 1990; Ross et al. 1997; Sacks et al. 1999; Stahl et al. 2001). Scalet et al. (1996) pointed out that predator-prey interactions influence both prey and predator populations. However, based on results of the present study, these interactions appear to be complex and differ among mammalian taxa.

Lack of support for the "problem-individual" paradigm among target predators could be explained by distribution of nests of Northern Bobwhites on the landscape and the predators involved. Stribling (1996) noted that nests of Northern Bobwhites are located in a number of habitat types. Linnell et al. (1999) suggested that a scattered distribution of prey, such as the distribution of artificial nests in this study, would increase encounter rates by predators without any search behavior required, and hypothesized that, under these conditions, problem individuals are less likely to appear because most individuals have opportunity to take the target prey without developing specialized behaviors.

Raccoons, Virginia Opossums, and Striped Skunks are omnivorous and opportunistic predators with strong preferences for seasonally available foods (McManus 1974; Gardner 1982; Godin 1982; Kaufmann 1982; Schwartz and Schwartz 2001). Wiens (1976) discussed population responses to patchy environments and noted the importance of prey density to responses of populations to patchiness. It appears likely that the habitat usually occupied by Northern Bobwhites (forest openings, open woods, fallow fields, and edges of cultivated fields; Stribling 1996) provides favorable and abundant foods (e.g., insects and other invertebrates, wild fruits, and small mammals; Merritt 1987; Schwartz and Schwartz 2001) for mammalian predators. Given that

number of individuals known alive for each species of predator was greater on the study site during the non-nesting period than the nesting period, as well as overall recapture rate and number of individuals captured more than 2 times (Table 1), it seems that the presence of eggs of Northern Bobwhites and Northern Bobwhites themselves had no unusual attraction for mesopredators. Neither Raccoons nor Virginia Opossums had a significant affinity for fields, which are managed intensively for Northern Bobwhites on Ames, and, because of the lack of individuals recaptured on artificial nests, the problem-individual hypothesis is not supported for these species. However, based on the number of captures in the present study, there was a distinct association between fields and Striped Skunks, which reflects a preference for this habitat (Nowak 1991). These habitats also are good for Northern Bobwhites throughout the year and not just during their breeding season (Stribling 1996). These mesopredators apparently used the study site and adjacent areas during the nesting period of Northern Bobwhites for foods other than those associated with Northern Bobwhites.

Being opportunistic, mesopredators may prey upon nests of Northern Bobwhites when they encounter them. Because of increased protein intake during formation and laying of eggs (Rosene 1969), eggs and Northern Bobwhites themselves represent foods of high nutritional value. However, because Northern Bobwhites on Ames provide only a limited source of food, optimal foraging is likely focused on more abundant and easily captured food items. Eggs and birds probably serve as a valuable supplemental food to more abundant food items. For example, Vickery et al. (1992) reported a positive correlation between predation by Striped Skunks on bird eggs and nestlings when that species was foraging for invertebrates. Such foraging patterns could partly explain reports that birds are preyed upon by Raccoons, Virginia Opossums, and Striped Skunks, although their occurrence in diets of these predators is small (McManus 1974; Kaufmann 1982; Godin 1982; Schwartz and Schwartz 2001).

In the present investigation, there was only one year where the most abundant species captured during the non-nesting season was responsible for the greater numbers of artificial nests preyed upon during the nesting-trapping season (Table 1). It appears that Raccoons, Virginia Opossums, and Striped Skunks, as individual species, had only a moderate impact on artificial nests (Table 1). However, as a subset of the community or mesopredator guild—a collection of species that use common resources in similar ways (Root 1967)—they had a much greater impact. In fact, Nicolaus (1987) stated that Raccoons, along with other mammals and birds, belonged to a guild of nest predators. Of artificial nests preyed upon in this study, Raccoons, Virginia Opossums, and Striped Skunks accounted for 10, 2, and 12% of losses, respectively. Collectively, there was a 24% loss of artificial nests attributable to this mesopredator guild.

Overall, the pattern of predation on artificial nests of Northern Bobwhites is apparently driven by a larger vertebrate-predator guild similar to the granivore guild (birds, rodents, and insects) reported in deserts of the southwestern United States (Brown and Davidson 1977). This vertebrate-predator guild, including both mammalian and reptilian predators, also has been documented by Staller et al. (2005). Because of the collective predation rates on artificial nests, most productive management (using multiple techniques; Jiminez and Conover 2001) for ground-nesting birds probably is best directed toward a vertebrate guild that includes not only mammalian predators but avian and reptilian predators as well. Because of the dynamic nature of community interactions (Meffe et al. 1997), it is not likely that single actions will resolve complex predator-prey relationships, which reflect the dynamic nature of the ecological world. At present, interaction among mammalian mesopredators is uncertain (Ladine 1997; Kissell and Kennedy 1992) and the impact of large vertebrate-predator guilds on prey species remains unclear. Future investigations are needed to more clearly understand these ecological issues.

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Reactions of Narwhals, *Monodon monoceros*, to Killer Whale, *Orcinus orca*, Attacks in the Eastern Canadian Arctic

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A Killer Whale attack on Narwhals was observed at Kakiak Point in Admiralty Inlet, Nunavut, Canada, in August 2005. Behavioral responses of both Narwhals and Killer Whales were documented by direct observation. Data collected from Narwhals instrumented with satellite-linked transmitters 5 days prior to the arrival of Killer Whales were used to examine changes in Narwhal movement patterns (e.g., dispersal and clumping) five days before the attack, during the attack, and five days after Killer Whales left the area. A minimum of four Narwhals were killed by 12-15 Killer Whales in a period of 6 hours. Narwhals showed a suite of behavioral changes in the immediate presence of Killer Whales including slow, quiet movements, travel close to the beach (<2 m from shore), use of very shallow water, and formation of tight groups at the surface. These behavioral changes are consistent with Inuit accounts of Killer Whale attacks on Narwhals. During the attack, Narwhals dispersed broadly, the groups were less clumped (standard deviation of inter-whale mean latitudes and longitudes), Narwhal space-use doubled from pre-attack home ranges of 347 km^2 to 767 km^2 (kernel 50% probability), and Narwhals shifted their distribution further south of the attack site. After the disappearance of Killer Whales, north-south dispersal of Narwhals contracted and was similar to pre-attack levels, total space use decreased slightly (599 km^2), yet west-east dispersal remained high. Narwhals were distributed significantly ($P < 0.001$) more broadly offshore in areas not used before the occurrence of Killer Whales. In general, short-term reactions of Narwhals to Killer Whale presence were obvious; yet normal behavior (as observed from shore) resumed shortly after Killer Whales left the area. Long-term (five day) Narwhal behavioral responses included increased dispersal of Narwhal groups over large offshore areas. This is among the few reports of eyewitness Killer Whale attacks on Narwhals in the high Arctic and is the first time changes in Narwhal behavior have been documented in response to a predation event through the use of satellite telemetry.

Key Words: Killer Whale, *Orcinus orca*, Narwhal, *Monodon monoceros*, predation, satellite telemetry, Admiralty Inlet, Nunavut, Canada.

Killer Whales (*Orcinus orca*) occur widely in Arctic waters, yet their abundance, movements, site fidelity, and specific distribution are poorly known (Forney and Wade 2006). Generally, Killer Whales are sighted during ice-free months and often near areas with high densities of other marine mammals, such as summering grounds for Belugas (*Delphinapterus leucas*) and Narwhals (*Monodon monoceros*). In the eastern Canadian High Arctic, this includes eastern Lancaster Sound and associated inlets or fjords around Baffin Island (e.g., Eclipse Sound, Admiralty Inlet, and Prince Regent Inlet) (Markham 1874; Reeves and Mitchell 1988).

Few eyewitness accounts are available of Killer Whale attacks on Narwhals (Steltner at al. 1984). This is because Killer Whales occur over large, sparsely inhabited Arctic areas and the timing and location of attacks are unpredictable. Thus, the majority of descriptions, both of Killer Whale attacks themselves and of the response of Narwhals, come from Inuit observations (Degerbøl and Freuchen 1935; Freuchen and Salomonsen 1961) or from scattered opportunistic reports (Campbell et al. 1988). Generally these accounts made by locals are limited in that observations extend only as far as what can be observed from shore and generally cover short time scales (hours). Also, Inuit observations of Killer Whale occurrence or Killer Whale attacks may not always be reported. There is little information about the natural mortality of Narwhals and generally, Killer Whales are assumed not to significantly depress Narwhal populations (Davis et al. 1980). Furthermore, the extent to which Killer Whales affect the behavior of Narwhals (e.g., movement patterns) is unknown.

In August 2005, a Killer Whale attack on Narwhals was observed from a camp operating a month-long Narwhal satellite tagging operation in Admiralty Inlet, Canada. Several kills of Narwhals by Killer Whales were inferred from vigorous surface and diving activity of Killer Whales within large oiled areas on the surface and congregations of seabirds. In combination with eyewitness observations of behavior of Narwhals and Killer Whales, data collected from satellite tags deployed on Narwhals up to five days before Killer Whales arrived in the area were used to examine clustering and dispersal of Narwhals prior to and following the predation events. These are the first quantitative movement data obtained from Narwhals subjected to Killer Whale predation.

Visual Observations of Attack

Killer Whales were reported by Inuit hunters in a camp about 3 km north of Kakiak Point (72°31'N 86°38'W), in Admiralty Inlet, Nunavut, Canada, on 19 August 2005. On 20 August, we witnessed a Killer Whale predation event on Narwhals just offshore of Kakiak Point. Approximately 12-15 Killer Whales arrived in a single group at Kakiak Point at 12 noon local time. At least several hundred Narwhals had been seen daily in the area for at least two weeks preceding the arrival of the Killer Whales and also on the morning of 20 August. On several occasions thousands of Narwhals had been seen moving past Kakiak Point over periods of 2-3 hours.

The Killer Whale group consisted of one adult male, 7-10 adult females, and several juveniles of undetermined sex. Narwhals were attacked less than 1 km from shore. At least two Narwhals were killed during the first observed attack between 12:00-13:00 local time. After this event, the Killer Whales left the vicinity of Kakiak Point for approximately 3 hours and returned at 16:00, when at least two more Narwhals were killed ~0.5 km from the coast. Killer Whales were not seen or reported again in the area until 25 August. Active subsistence hunting for Narwhals was practiced at several hunting camps along the shore north and south of the research camp.

The four independent kill events occurred over a 6 hour period in daylight hours. Narwhal kills were inferred from large oil/blubber slicks at the surface, congregations and diving of Fulmars (*Fulmarus glacialis*) in surface waters, and focal movements of Killer Whales diving in the center of oiled areas for 15-30 minutes at a time (Figure 1). No body parts or pieces of Narwhals were directly seen.

Narwhal Movements

Narwhal satellite tagging operations were ongoing prior to the Killer Whales' arrival at Kakiak Point. Narwhals were captured using nets set perpendicular to the shoreline 50-100 m from shore (details described in Dietz et al. 2001) and instrumented with SPOT4 and SPOT5 satellite tags made by Wildlife Computers (Redmond, Washington). Tags recorded daily geographic positions based on Doppler shift of tag transmissions received by polar orbiting satellites through Service Argos (Harris et al. 1990). Transmitters were attached to Narwhals on the dorsal ridge with three 6-10 mm polyethylene pins. The Narwhals were usually released after less than 30 minutes (Table 1).

Only data collected from Narwhals instrumented prior to the Killer Whales' arrival were used in the analysis to control for differences in sample size (number of individuals monitored before and after the predation event). Since the Narwhals were instrumented and released on different occasions, they were assumed to represent different groups or pods. Average daily geographic positions were calculated for each Narwhal based on good quality Argos locations (location quality >=0). Average daily positions for each whale were averaged to create inter-whale means. The standard deviation of daily average inter-whale positions was calculated for each of three time periods: five days before Killer Whales arrived (14–18 August), during the immediate Killer Whale observations or attacks (19–20 August), and five days after the Killer Whale attack (21–25 August) when no Killer Whales were seen in the area. Narwhals were distributed along a north-south gradient along the west coast of Admiralty Inlet; therefore the variation in latitude was interpreted as coastwise dispersion and the variation in longitude was interpreted as inshore-offshore dispersion. Narwhal space-use patterns were quantified in each of the three time periods with a kernel home range polygon (probabilistic measure of space use) [ArcView 3.1 Environmental Systems Research Institute] based on average daily positions from each whale.

Results

Pre-attack Narwhal behavior (> 5 days)

Narwhals observed passing Kakiak Point before the Killer Whale attack moved in groups of 3-8 whales at a distance of 20-200 m from the beach. Most whales were heading south. Between 14 and 17 August, seven Narwhals were instrumented with satellite tags before the Killer Whales arrived in the vicinity of Kakiak Point (Table 1). These Narwhals moved along the western side of Admiralty Inlet south of Kakiak Point and less than 1-2 km from shore. No tagged Narwhals were located in the center or eastern side of the inlet and the linear home range along the west coast was <100 km.

TABLE 1. Seven Narwhals instrumented with satellite transmitters prior to Killer Whale occurrence and attack at Kakiak Point, Admiralty Inlet, Canada, 2005. Calf accompanying female on 17 September 2005 was not tagged.

ID	Tagging date	Time of release	Sex	Body length (cm)
20685	14 September 2005	15:06	F	360
20686	14 September 2005	15:56	M	483
20689	17 September 2005	06:25	F	360
37235	17 September 2005	10:45	F + calf	358
37236	17 September 2005	21:20	F	380
37280	17 September 2005	21:27	F	380
37282	17 September 2005	21:45	F	364

FIGURE 1. Oil film on the surface created by Killer Whales feeding on Narwhals in Admiralty Inlet, Canada, August 2005. Large aggregations of Fulmars appeared in the area shortly after each kill. Photo by M. P. Heide-Jorgensen.

The standard deviation of average daily positions indicated that dispersal of Narwhal groups varied approximately 19.9 km north-south, and 13 km west-east before Killer Whales arrived (Table 2). The core of the pre-attack kernel home range (50% probability area) was concentrated just offshore of Kakiak Point and distributed along the west coast of the inlet encompassing 347 km^2 (Table 2).

Immediate Reactions of Narwhals to Killer Whale Attack

On 19 August, Killer Whales were reported by Inuit hunters north of the camp, yet no detailed observations of predation events or behavior were collected. On that day, we observed Narwhals passing very close to the shore (within the surf zone approximately 2-3 m from land) and remaining still at the surface in large groups.

TABLE 2. Dispersal of Narwhals before, during, and after a Killer Whale attack in August 2005 as measured by the distance between average daily satellite positions obtained from seven Narwhals instrumented at Kakiak Point prior to the arrival of the Killer Whales. The standard deviation (SD) in latitude and longitude is reported and also converted to north-south dispersal and west-east dispersal with distance units of km.

	Latitude SD	Longitude SD	N-S dispersal (km)	W-E dispersal (km)	Kernel core (50%) km^2
Before attack (5 days)	0.18	0.12	19.9	13.0	347
During attack (2 days)	0.33	0.29	36.4	32.8	767
After attack (5 days)	0.18	0.25	19.7	27.6	599

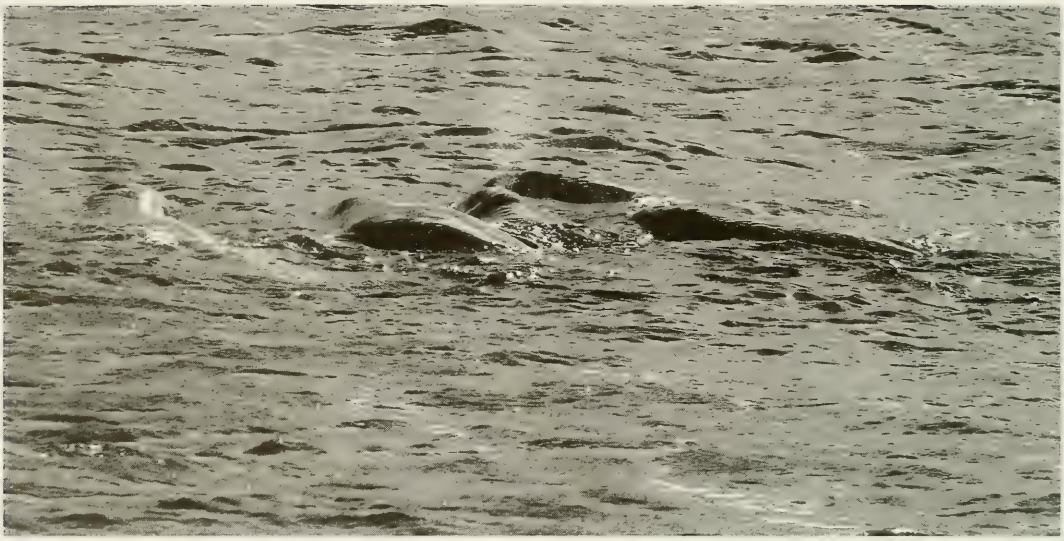

FIGURE 2. When Killer Whales arrived in the vicinity of Kakiak Point, Narwhals formed tight groups and remained close to the shore lying still. Photo M. P. Heide-Jørgensen.

On 20 August, Killer Whales were visually observed arriving at Kakiak Point traveling a northbound route along the west side of the inlet. Narwhals were already present in the coastal area (<500 m from the shore) around Kakiak Point and in a small bay just behind the point. When the Killer Whales were within 2-4 km, Narwhals suddenly moved closer to the shore in shallow water (<2 m). Some Narwhals formed tight groups and others moved slowly or lay very still at the surface (Figure 2). One Narwhal stranded on a flat gravel beach (<0.5 m of water) and made violent tail thrashes for >30 seconds (Figure 3), either as a warning signal or in attempts to remove itself from the beach.

Satellite telemetry data indicated instrumented Narwhals clearly responded to the presence of Killer Whales (Figure 4). During the attack, both the north-

FIGURE 3. During the Killer Whale attack, Narwhals beached themselves in sandy areas and made tail slaps. Coastline can be seen in lower left. Photo by K. L. Laidre.

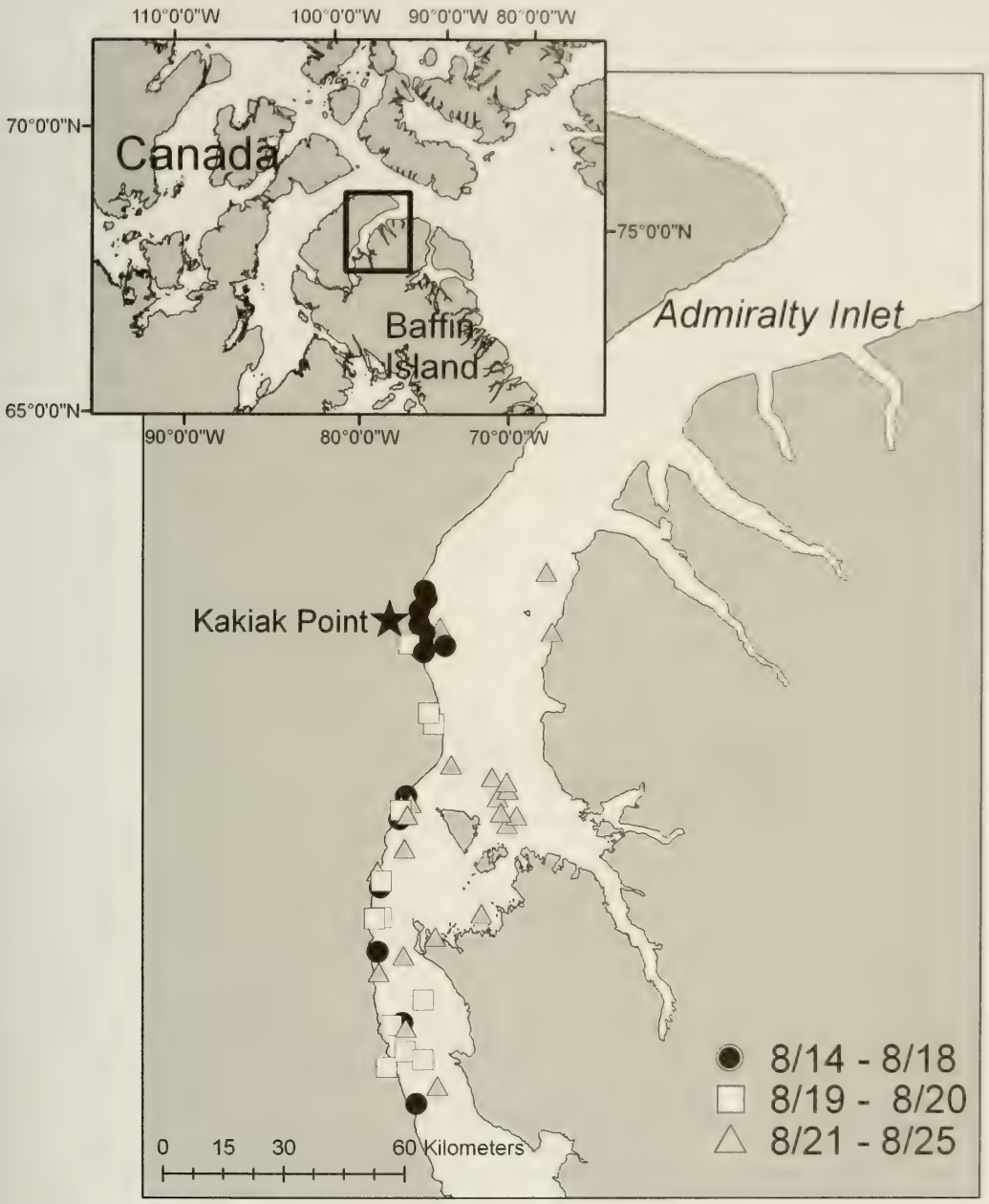

FIGURE 4. Average daily positions received from seven Narwhals instrumented with satellite tags before the Killer Whale attack. Average positions are shown in 3 time periods: the five days prior to Killer Whale arrival (14-18 August), the two days Killer Whales were observed (19-20 August), and the five days after the Killer Whale departure (21-25

south and west-east dispersal (as measured by inter-whale mean latitude and longitude standard deviations) doubled (Table 2). When Killer Whales were in the area, the core kernel home range shifted south by approximately 80 km and doubled in size (767 km^2) (Figure 5, Table 2). Generally, the groups of Narwhals were more widely dispersed in all directions during the attack than before the Killer Whales arrived.

Post-Attack Narwhal Behavior (>5 days)

Narwhals resumed their normal swimming behavior and distance from the coast within an hour after the Killer Whales left the locality. No whales were ob-

served closer than 20 m from the beach and tight groups at the surface broke-up and dispersed.

The instrumented Narwhals moved offshore and utilized a wider area after the attack (ANOVA on longitude, $F_{2,9}=17.6$, $P < 0.001$). Standard deviations of the mean inter-whale latitude (19.7 km) were reduced by half after the departure of the Killer Whales and were nearly identical to pre-attack values (19.9 km), demonstrating a contraction of the north-south dispersal (Table 2). The mean inter-whale longitude standard deviation was slightly lower than during the Killer Whale attack (27.6 km), yet did not return to pre-attack value, indicating a general inshore-offshore dispersal from the attack site.

Post-attack kernel home range core area (599 km^2) was less than that during the attack, yet the core area was located east of the pre-attack core in the center of Admiralty Inlet extending across to the eastern shoreline (Figure 5, Table 2). In general the Narwhal groups maintained a wider offshore dispersal and ranged more widely than before the Killer Whale attack.

Discussion

Narwhals exhibited clear reactions to the immediate presence of Killer Whales. Their suite of behaviors included slow, quiet movements, travel very close to the beach in the surf zone, movement into very shallow water less than 2 m, and formation of tight groups at the surface. All of these observations are consistent with Inuit accounts. Within an hour after the Killer Whale attack and when Killer Whales had left the area, direct observations suggested Narwhals resumed normal behavior (e.g., distances from the coast increased and tight groups dispersed).

Satellite telemetry data revealed long-term (multi-day) observations of Narwhal movements before and after the attack, in addition to observations during the attack. Average daily positions indicated that Narwhal groups were more dispersed during and after the Killer Whale attack. Dispersal primarily increased in the offshore (west-east) direction as measured by longitude standard deviations and home ranges. Cores of area use calculations demonstrated that the range of Narwhal movements increased two-fold during the Killer Whale attack, shifted south in a direction away from the attack point, and then expanded to offshore areas afterwards (where Narwhals had not been observed previously in 2005).

Later in the season, Killer Whales were reported in "fairly large numbers" in Admiralty Inlet and vicinity (especially Adams Sound) until October 2005 (Niore Annie Iqalukjuak, Arctic Bay, personal communication). The exact location and movements of these Killer Whales between August and September are not known, nor is it known whether other attacks on Narwhals occurred. Satellite tagging data showed that Narwhals remained in Admiralty Inlet until the third week of October, after which the southbound fall migration was underway. Thus, it appears that even on longer time scales (~2 months) Narwhals do not alter their site fidelity to the summering grounds (see Heide-Jørgensen et al. 2003) or depart early in response to the presence of Killer Whales.

Killer Whales were also reported in Admiralty Inlet in late August 2004 but no data or specific observations were available. It is unknown if the occurrence observed in 2004 involved the same group of Killer Whales as observed in 2005. On 25 August 2004, one of the authors (J.R.O.) observed a young Bowhead Whale (*Balaena mysticetus*) killed by Killer Whales at Kakiak Point, and bones were found on the beach less than 1 km away from the attack site the following year in 2005. Furthermore, on the same date as the attack reported here, several Killer Whales were observed attacking Narwhals in Repulse Bay, Hudson Strait, Canada (Joani Kringayark, personal communication). Therefore, at least two separate groups of Killer Whales feed on Narwhals on their summering grounds in the eastern Canadian Arctic in August.

When Killer Whales attacked Narwhals, there was limited action at the surface with no struggle or splashing observed. Killer Whales consumed the Narwhals below the surface of the water, and made multiple dives in the center of oiled areas (presumed kills) for 15-20 minutes. An eyewitness account of a Killer Whale attack on Narwhals in Inglefield Bredning, West Greenland in August 2004 noted Killer Whales jumping on top of Narwhals and holding them under the surface until they drowned (Gretchen Freund, personal communication).

If the predation level observed at Kakiak Point (4 Narwhals over 6 hours) is representative of the daily predation level of a similar sized pod of Killer Whales in the High Arctic, then consumption of Narwhals during a two-month stay in Admiralty Inlet would amount to approximately 200-300 Narwhals. A photographic survey estimated 5,556 (CV=0.22) Narwhals in Admiralty Inlet in 1984 (Richard et al. 1994). If the photographic survey results are corrected for whales that were diving using a correction factor of 0.38 (0.06) developed by Heide-Jørgensen (2004), then the abundance would have been in the order of 14,621(0.23). A mortality of 200-300 Narwhals from Killer Whale predation would represent <3% of this abundance estimate. It is possible that predation constitutes a larger proportion of the annual natural mortality of Narwhals than previously expected; however, it is not known if this natural mortality is fully compensatory. In this case, a continued high level of Killer Whale predation in combination with a population reduction by subsistence harvest could reinforce a decline. Killer Whale predation has been responsible for the decline of sea otters in Alaska (Estes et al. 1998; Doroff et al. 2003) and has been hypothesized as the driver for a decline of other top predators in the North Pacific (Springer et al. 2003).

The reason Narwhals occupy deep and narrow fjords during summer is unknown and it has been hypothesized that their summer distribution may be related to

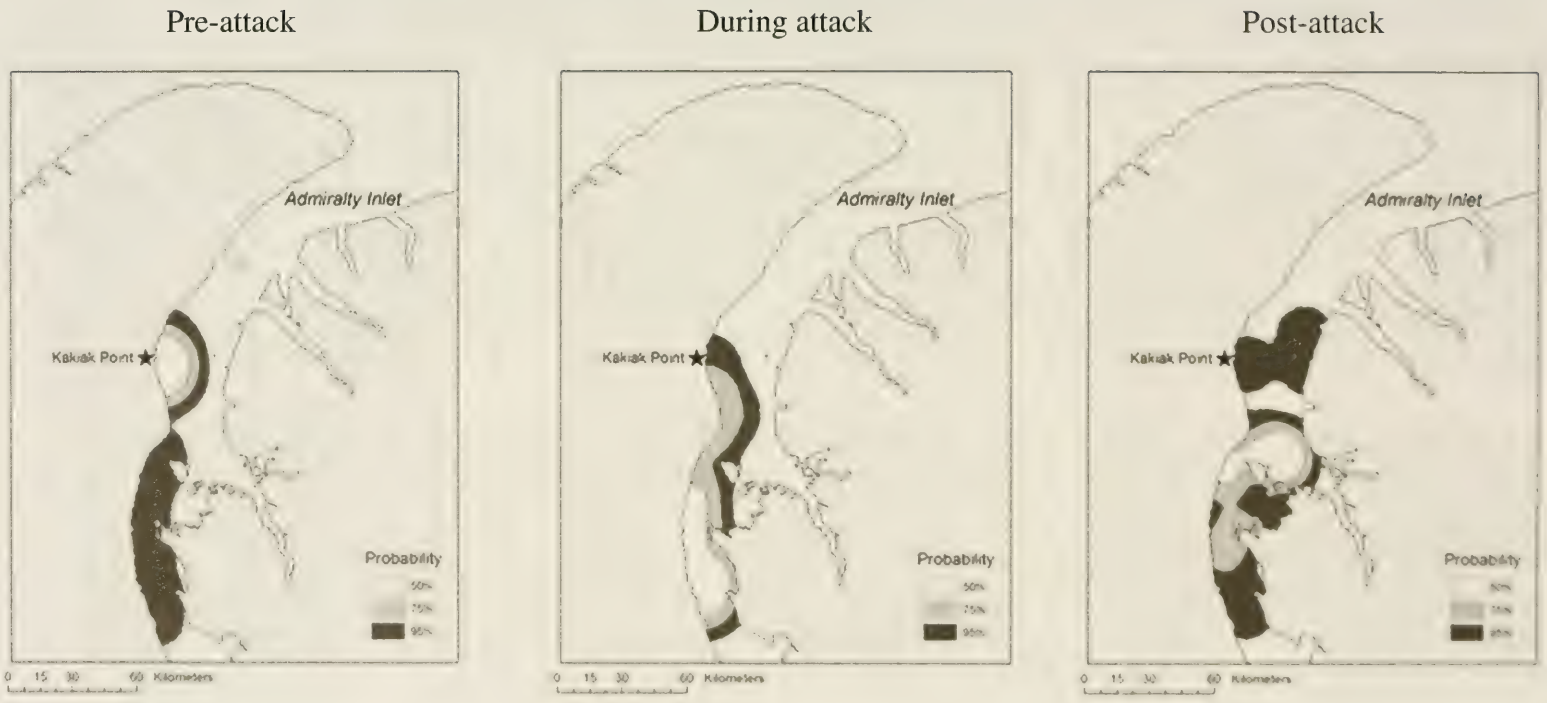

FIGURE 5. Narwhal space-use patterns before, during, and after the Killer Whale attack estimated with kernel home range polygons (50% is white). Home ranges were calculated for three time periods: The five days prior to Killer Whale arrival (14-18 August), the two days Killer Whales were observed (19-20 August), and the five days after the Killer Whale departure (21 August-25 August). The Killer Whale attack was observed at Kakiak Point (star symbol) on the west coast.

potential predation by Killer Whales (Kingsley et al. 1994). Narwhals feed very little during the summer season (Laidre and Heide-Jørgensen 2005a), and summering grounds do not appear to be related to calving needs given calves are born in the spring. The summer refuge from Killer Whales hypothesis lacks conclusive evidence as Narwhal distribution in other seasons is clearly driven by biological needs, such as sea ice formation, open water, or access to prey resources (Laidre and Heide-Jørgensen 2005b) and Narwhals did not seek refuge or depart early in response to the observed attack. Little is known about what proportion of different types of Killer Whales occurs in Arctic waters (i.e., mammal-eating vs. fish-eating). Stomach contents of 30 Killer Whales harvested in Disko Bay, West Greenland in February 2003 contained only Lumpsucker fish (*Cyclopterus lumpus*), despite the fact these Killer Whales were taken in an area with a large abundance of Bowhead Whales, Ringed Seals (*Phoca hispida*), Narwhals, Belugas, and other potential marine mammal prey items (Greenland Institute of Natural Resources, unpublished data).

Few observations have been collected of Killer Whales during winter in Arctic ice conditions. It is generally assumed that Killer Whales avoid the Arctic pack ice (Heide-Jørgensen 1988) despite the fact many Killer Whales occur and thrive in the dense pack-ice of the Antarctic. It is possible that changes in sea ice (lighter sea ice cover and earlier break-up) will alter (or have already altered) the occurrence of Killer Whales in Arctic waters. These changes may facilitate increased or longer visits by Killer Whales to ice-free Arctic areas.

The predicted reduction of annual sea ice, together with a longer open water season, will likely lead to an increase in Killer Whale predation on Narwhals. At the same time, reduced sea ice will also decrease the probability that Narwhals succumb in ice entrapments (also known as Sassats), another important source of natural mortality (Laidre and Heide-Jørgensen 2005b). It is unclear how the interplay between these two elements of natural mortality will evolve under changing sea ice regimes.

Acknowledgments

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Urine-marking and Ground-scratching by Free-ranging Arctic Wolves, *Canis lupus arctos,* in Summer

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Mech, L. David 2006. Urine-marking and ground-scratching by free-ranging Arctic Wolves, *Canis lupus arctos*, in summer. Canadian Field Naturalist 120(4): 466–470.

Urine-marking and ground-scratching were observed in an Arctic Wolf (*Canis lupus*) pack on Ellesmere Island, Nunavut, Canada, during 16 summers between 1986 and 2005. All previously known urination postures and ground-scratching by breeding males and females were seen, and incidence of marking and scratching was greatest when non-pack wolves were present. Observations of urine-marking of food remains supported the conclusion from a captive Wolf study that such marking signals lack of edible food.

Key Words: Arctic Wolf, *Canis lupus arctos*, ground-scratching, odor, scent-marking, territoriality, urine-marking, Ellesmere Island, Nunavut, Canada.

Scent-marking by Wolves (*Canis lupus*) includes both urine-marking and ground-scratching, usually by dominant breeding males and females (Peters and Mech 1975; Harrington and Asa 2003). Most information about Wolf urine-marking has been collected during winter by tracking Wolves in the snow (Peters and Mech 1975; Rothman and Mech 1979; Paquet and Fuller 1990; Paquet 1991; Zub et al. 2003) or during other seasons by studying captive Wolves (Harrington 1981; Raymer et al. 1984, 1986; Asa et al. 1986, 1990; Mertl-Millhollen et al. 1986; Ryon and Brown 1990; Barja and Miguel 2004). Only scattered mentions can be found of free-ranging Wolves urine-marking during summer (Clark 1971; Haber 1977; Mech 1991, 1995), and only one study of Wolf ground-scratching in summer has been done (Zub et al. 2003). Detailed information about urine-marking in wild Wolves during summer is lacking because, with a few exceptions (Murie 1944; Clarke 1971; Haber 1977; Mech 1988), it has been difficult to observe Wolves in the wild during summer because of their usual fear and avoidance of humans.

I observed free-ranging Wolves in the Canadian High Arctic over a period of 20 summers, where the Wolves are highly tolerant of humans (Parmelee 1964; Miller 1978; Mech 1988). There I obtained detailed data on their urine-marking and ground-scratching behavior.

Study Area

The study area includes about 2600 km^2 of the Fosheim Peninsula east, north and west of Eureka on Ellesmere Island (80°N latitude, 86°W longitude), Nunavut, Canada. During summer, daylight is constant. The area includes shoreline, hills, lowlands, creek bottoms and the area around Blacktop Ridge. Contrary to much of the surrounding region, this area is generally snow- and ice-free in summer, and contains rock, gravel, bare soil and scattered tundra and northern wetland vegetation. Wolves, Muskoxen (*Ovibos moschatus*) and Arctic Hares (*Lepus arcticus*) have long been common in the area (Tener 1954), and Wolves have denned there over decades or possibly centuries (Parmelee 1964; Grace 1976; Mech 1988; Mech and Packard 1990). Aside from intermittent scavenging around a weather station and military base, the main foods of the Wolves I studied were Muskoxen and Arctic Hares (Tener 1954), although seals (*Phoca* spp.) and Lemmings (*Dicrostonyx groenlandicus*) are also taken occasionally.

Methods

The Wolves I studied live far enough from exploitation and persecution by humans that they are relatively unafraid of people (Mech 1988, 1995). During 1986, I habituated a Wolf pack to my presence and reinforced the habituation each summer I observed them. The pack frequented the same area each summer and usually used the same den or nearby dens. The habituation allowed me and an associate to remain with the Wolves daily, to recognize them individually, and to watch them regularly from 10 to 200-m away, and often as close as 1 m (Mech 1988, 1995). This pack had disappeared by 2001, but by 2003 another pack, similarly habituated, was present (Mech 2005).

Although I made no attempt to systematically or completely record every urination or scratching made by each Wolf, I did note as many such events as I could, usually those made by breeding males and females, while I was observing general behavior. I identified breeding females by observing them nursing pups or by the presence of obvious teats. Breeding males were identified by their dominance over other males and their

TABLE 1. Yearly distribution of observed urine marks made by breeding male (RLUs and STUs) and breeding female (FLUs and SQUs) Arctic Wolves, Ellesmere Island, Nunavut, Canada, 1986-1996, including only years in which observations covered at least four weekly periods.[1]

Summers	Number of Weekly Periods	Male		Female		Total	
		Marks	Marks Per Period	Marks	Marks Per Period	Marks	Marks Per Period
1986	4	7	1.8	0	0	7	1.8
1987	5	7	1.4	0	0	7	1.4
1988	7	9	1.3	0	0	9	1.3
1989	8	5	0.6	5	0.6	10	1.3
1990	8	11	1.4	18	2.3	29	3.6
1991	8	11	1.4	22	2.8	33	4.1
1992	6	29	4.8	14	2.3	43	7.2
1993	6	12	2.0	13	2.2	25	4.2
1994[2]	5	3	0.6	5	1.0	8	1.6
1996	6	27	4.5	14	2.3	41	6.8

[1] Because of potential biases in times and methods of data collection, fine comparisons are not necessarily valid.
[2] 1995 covered only two periods.

overall initiative and control of pack activities (Schenkel 1947; Mech 1970, 1999; Peterson et al. 2002).

I collected data over periods of 1-8 weeks from June through early August 1986-2005, except 1997, 1999, 2000, and 2001. Most of the longest data collection took place 1986-1996 (Table 1). Because study periods, pack behavior, and observation emphasis varied over the summers and years (Table 2), biases in the collection of urine-marking and ground-scratching data over both the total duration of the study and over the seasonal extent of the study each summer probably affected the data collected. Thus only the data on ratios of marking postures should be unbiased enough to warrant statistical testing, and I make no attempt to draw detailed conclusions from the untested data. However, these data are still useful to make broader conclusions and to establish several facts that heretofore were unknown or poorly documented in free-ranging Wolves during summer.

Results

I identified three breeding female and three breeding male Wolves, plus one pair without pups, that traveled, hunted and marked together (Mech 1995, 2005, and unpublished). I recorded males making 121 raised-leg urinations (RLU) 22 June – 8 August and 30 standing urinations (STU) 15 June – 10 August; and females, 47 flexed-leg urinations (FLU) 15 June – 3 August, and 70 squat urinations (SQU) 15 June – 29 July (Table 2). The proportion of male RLUs was significantly higher than the proportion of female FLUs ($\chi^2 = 45.01$; $P < 0.0001$; $d.f. = 1$). The number of both male and female marks I observed per weekly observation period appeared to decrease over the summer (Table 2). The number of recorded urinations per observation period varied by year from 1.3 to 7.2. (Table 1).

In addition to FLUs by breeding females, I also observed a pre-breeding female (bred the next year) FLU twice on 6 August. An associate had also seen this animal do "slight FLUs" three times on 13 July (see Discussion.)

I observed double marking (Rothman and Mech 1979) 24 times between 26 June and 3 August. Double marking is marking of a single location by both members of a mated pair within a few minutes of each other and can be initiated by either member. Of eight possible combinations of double-marking postures (RLUs or STUs initiated by males, FLUs or SQUs initiated by females) I observed five of the combinations, with those involving RLUs and FLUs significantly predominating (Table 3).

I observed ground-scratching by both male and female breeding Wolves or by either individual as early as 15 June and as late as 31 July. The pre-breeding female (above) scratched as late as 6 August. Besides the breeders' and pre-breeder's ground-scratching, a non-breeding female was observed scratching during two different summers, the same Wolf each year. Of 16 summers when I observed breeding or mated Wolves, I recorded no scratching by them during seven of those years and three or less scratching events during six other summers.

Only during 1992, 1993, and 1996 did I see Wolves do much scratching, and both male and female breeders did so. During the above years, the breeding pair I studied, the same individuals each year, scratched regularly. Those two individuals had also been the breeders since 1989, but I saw little scratching during 1989-1991, 1994 or 1995. During 1992, the breeding pair scratched (and urine-marked – Table 2) much more than I had seen them in the past. They scratched (and urine-marked) especially (1) near a Muskox they had killed and at which a non-pack Wolf had also been feeding a few minutes before, (2) near a garbage dump where at least one non-pack Wolf had been feeding regularly and (3) along the easternmost location (ter-

TABLE 2. Weekly distribution of observed urine marks made by breeding male (RLUs and STUs) and breeding female (FLUs and SQUs) Arctic Wolves, Ellesmere Island, Nunavut, Canada, 1986-2005.[1]

		Male		Female		Total	
Summers	Number Periods	Marks	Marks Per Period	Marks	Marks Per Period	Marks	Per Period
15-22 June	5	3	0.6	9	1.8	12	2.4
23-30 June	9	39	4.3	18	2.0	57	6.3
1-7 July	11	31	2.8	31	2.9	62	5.6
8-14 July	13	36	2.8	36	2.8	72	5.5
15-21 July	10	16	1.6	16	1.6	32	3.2
22-28 July	9	20	2.2	4	0.4	24	2.7
29 July–4 August	9	4	0.4	3	0.3	7	0.7
5-10 August	6	2	0.3	0	0	2	0.3

[1] Because of potential biases in times and methods of data collection, fine comparisons are not necessarily valid.

ritory boundary?) where we saw them that summer. During 1996, the breeding female scratched and urine-marked while trying to force a Muskox away from the den. In another study area, in the Canadian Northwest Territories, I also observed wolves scratching several times at a Red Fox (*Vulpes fulva*) den (Mech unpublished) during August.

I observed ground-scratching in various elimination contexts: (1) with no other marking behavior, (2) followed by FLU or RLU, (3) preceded by FLU, RLU or SQU, (4) preceded and followed by FLU, or (5) preceded by defecation, similar to the findings of Peters and Mech (1975) and Mertl-Millhollen et al. (1986).

I also observed urine-marking in relation to food remains as Harrington (1981) also did. Breeding males and females used all four kinds of urine postures in marking uneaten food remains or prey odors including the following (1) Arctic Hare intestines; (2) chewed bones; (3) Arctic Hare stomach contents; (4) locations where regurgitated or other food had recently been eaten; (5) old kills; (6) the head of a recent Muskox kill; (7) a putrid Muskox carcass which they sometimes fed on but often passed up; (8) where another Wolf had tried but failed to catch a lemming; and (9) at caches of which they or another Wolf (including a pup) had just consumed the contents.

TABLE 3. Order and type of urination postures in double urine marks[1] by arctic Wolves observed during summers 1986-2005 on Ellesmere Island, Nunavut, Canada. (Males do raised-leg [RLU] and standing [STU] urinations, and females, flexed-leg [FLU] and squat [SQU] urinations.)

	Male Initiated
RLU–FLU	6
RLU-SQU	1
STU-FLU	2
STU-SQU	0
	Female Initiated
FLU-RLU	9
FLU-STU	0
SQU-RLU	6
SQU-STU	0

[1] Urination sequences involving RLUs or FLUs occurred significantly more often than expected by chance ($\chi^2 = 6.86$; $P = 0.03$; $d.f. = 1$).

Discussion

Captive breeding male and female Wolves urine-mark at all times of the year, with the peak frequency during the winter breeding season, and with all studies except that by Ryon and Brown (1990) observing that males tend to mark more year around than females (Peters and Mech 1975; Mertl-Millhollen et al. 1986; Asa et al. 1990; Barja and Miguel 2004).

Information on urine-marking frequencies during summer in captive wolves varies considerably. In one case, where the breeding pairs had pups, both males and females increased their marking rate during summer (Mertl-Millhollen et al. 1986). In another, where "reproductive pairs" were studied, but no pups were born, the males increased their rate of RLU during summer, but the females did not increase their FLU rate (Barja and Miguel 2004). In two others, where no pups were involved, the RLU and FLU rates of dominant males and females reached their minimum in summer (Asa et al. 1990; Ryon and Brown 1990). Testosterone tends to decrease to a minimum during summer (Asa et al. 1990), as does testis size (Mech 2006). This relationship suggests that urine-marking, which depends on testosterone (Asa et al. 1990), would also decrease then. However, the variations found in the studies cited above suggest that the social milieu can affect the relationship between testosterone and urine-marking, so that the relationship might not always be so tight, as Asa et al. (1990) also found. Because of possible biases mentioned earlier, my data can add little to this subject, although conceivably the extreme variation seen in my data reflect actual behavioral variation similar to that reported in captive Wolves. In that respect, my data on ground-scratching are instructive.

This study documents for the first time that wild Wolves urine-mark throughout summer, using all known urine postures, including double-marking, but

that the proportion of RLUs and FLUs to STUs and SQUs is lower then than in captive Wolves during winter (Asa et al. 1990) when RLUs and FLUs tend to predominate (Peters and Mech 1975).

The fact that a pre-breeding female was seen FLUing ("RLU" in Mech 1995) is of special interest. Based on my observation of this pack the previous three summers, I inferred that she had been born two years earlier. This pre-breeder began dominating the breeding female, her apparent mother, about the time the pre-breeder began FLUing. The pre-breeder bred the next year, apparently with her father, and remained bonded to him for the next six years, producing pups during four of them while the mother remained with the pack for two more years without being seen FLUing, and then disappeared (Mech 1995 and unpublished). This behavior of a young offspring starting to FLU or RLU and challenging its same-sex parent for dominance is similar to that seen in a captive colony (Asa et al. 1990).

Previous information about free-ranging Wolves ground-scratching in summer comes only from a single study which concluded that between April and September, ground-scratching was low and stable (Zub et al. 2003). I could make no similar seasonal comparison, but it was clear from my multi-summer observations that the degree of ground-scratching varied considerably from summer to summer, with no scratching seen some summers and regular scratching during others. In 1992, the year of most scratching, the presence of non-pack Wolves seemed to be the pertinent stimulus. It was the only year I observed the Wolves I had been studying chase or attack outsiders on three occasions (Mech 1993). It was also the year when I recorded the highest amount of urine-marking (Table 1), when the Wolves usually were extra alert and looking around intently when they marked and scratched, and when they marked their easternmost locations, suggesting a territory boundary. My impression during these times was that the Wolves were in a high state of arousal and aggressiveness. Both breeding males and females scratched about equally, contrary to Mertl-Millhollen et al. (1986) who found primarily females scratching.

Regarding marking of food remains, my observations confirm those of Harrington (1981) on captive Wolves and support his conclusion that marking of recently emptied food caches (and by extension from my observations, other inedible food remains) signals that a site contains no more edible food despite lingering odors.

In summary, this study documents that much information learned about Wolf urine-marking behavior in captivity during summer applies to free-ranging Wolves; it extends information about ground-scratching; and it places information from captive studies about urine-marking of food remains in its natural context.

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Notes

Double Marking in Arctic Wolves, *Canis lupus arctos*: Influence of Order on Posture

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Harrington, F. H. 2006. Double marking in Arctic Wolves, *Canis lupus arctos*: Influence of order on posture. Canadian Field Naturalist 120(4): 471–473.

Double marking by Arctic Wolves (*Canis lupus arctos*) was recorded by Mech (2006) from a pack on Ellesmere Island, Nunavut, Canada, during 16 summers between 1986 and 2005. Using his data on the frequency of occurrence for each of the four postures used by Wolves for urine marking (males – raised leg and stand urinations; females – flexed leg and squat urinations), the probabilities of occurrence for each of eight possible double mark sequences were determined and compared with observed frequencies. Females were somewhat but not significantly more likely to initiate double mark sequences. There was no evidence for any bias in the posture used to initiate a double mark sequence, but assertive postures by both males and females nearly always completed the sequence, occurring much more often than expected by chance.

Key Words: Arctic Wolves, *Canis lupus arctos*, scent-marking, double marking, pair bonding, mate guarding, urine-marking, Ellesmere Island, Nunavut, Canada.

Double marking, in which a mated pair urine marks a single site in quick succession, is commonly observed in Wolves (*Canis lupus*) (Harrington and Asa 2003), although evidence from wild Wolves is often inferred from the pattern of urine marks on snow (Peters and Mech 1975; Rothman and Mech 1979). Direct observations, such as those of Mech (2006), permit the identification of the postures used in marking, from which underlying motivation might be inferred. Males may use either raised-leg urinations (RLUs) or standing urinations (STUs) and females either flexed-leg urinations (FLUs) or squat urinations (SQUs), with the former posture for either sex considered to be more reflective of aggressive or assertive motivation (reviewed by Harrington and Asa 2003). Thus there are eight possible forms that a double marking sequence can take. Mech (2006) has presented data on urine-marking in Wolves, recorded by direct observation from Arctic Wolves, *Canis lupus actus*, during the summer. Among those data are 24 cases of double marking (Table 1), and the reported finding that the more assertive postures (RLUs and FLUs) occur more frequently in double marking. The purpose of this note is to extend the analysis of those data in order to offer more insight into the motivation behind double marking.

TABLE 1. Urination postures used during double marking by Arctic Wolves during summers 1986-2005 on Ellesmere Island, Nunavut, Canada. Male postures: raised-leg [RLU] and standing [STU] urinations; female postures: flexed-leg [FLU] and squat [SQU] urinations. (Data from Mech 2006).

	Male Initiated Double Marks
RLU–FLU	6
RLU-SQU	1
STU-FLU	2
STU-SQU	0
	Female Initiated Double Marks
FLU-RLU	9
FLU-STU	0
SQU-RLU	6
SQU-STU	0

Methods

A dominant adult Wolf may urine-mark using either posture appropriate for its sex. This analysis seeks to determine whether there is a non-random pattern in the use of either posture, by either sex, in double marking compared to urine-marking in general. Therefore I first determined the overall frequency of each urination posture that occurred exclusive of double marking (Table 2) to yield two base rates, one for the probability of occurrence for each of the postures overall and another for the probability of the occurrence of each form within a sex. From these probabilities, one can calculate expected frequencies for each form of double mark, under the assumption that the postures used in double marking simply represent random combinations of the postures utilized otherwise. This is done by multiplying the value from row 1 (the random probability the posture will occur overall and thus initiate a sequence) with the value from row 2 (the random probability the other sex will use one of its two alternative postures to complete the double mark). Thus, for example, the

TABLE 2. Calculation of the probability of occurrence for each of the urination postures used by Arctic Wolves on Ellesmere Island, Nunavut, Canada during summers 1986-2005.

	Urination posture				
	RLU	STU	FLU	SQU	Total marks
Total marks	121	30	47	70	268
Minus double marks	-22	-2	-17	-7	-48
Non-double mark urinations	99	28	30	63	220
(1) Probability of posture (overall)	0.45	0.13	0.14	0.28	1.00
(2) Probability of posture (within sex)	0.78	0.22	0.32	0.68	1.00/sex

TABLE 3. Expected and observed frequencies of occurrence for each of the eight different forms of Wolf double marking, for Arctic Wolves on Ellesmere Island, Nunavut, Canada during summers 1986-2005. Expected frequencies are based on the combined probability of occurrence for each posture in the sequence (from data in Table 2), under the assumption of independence of occurrence for each posture type and based on a sample size of 24.

	Double urination mark sequence			
Male initiated sequences	RLU-FLU	RLU-SQU	STU-FLU	STU-SQU
Expected frequency	3.5	7.3	1.0	2.1
Observed frequency	6	1	2	0
Probability of occurrence	0.144	0.306	0.042	0.088
Female initiated sequences	FLU-RLU	FLU-STU	SQU-RLU	SQU-STU
Expected frequency	2.6	0.7	5.2	1.5
Observed frequency	9	0	6	0
Probability of occurrence	0.109	0.031	0.218	0.062

probability for an RLU/SQU double mark to occur at random is 0.45•0.68=0.306, whereas a double mark in the reverse order (SQU/ RLU) is expected less often (0.28•0.78=0.218), primarily because males are more likely to use dominant postures overall than are females (Table 3).

Results

Three questions can be addressed using the probabilities generated in Table 3. First, is one sex more likely to initiate a double marking sequence? Although females initiated 63% of the double marks observed, compared to the expected frequency of 42%, this increase was not greater than expected by chance ($\chi^2 = 2.10$, df = 1, ns). Second, is the first mark more likely to be from an assertive posture than otherwise? Again, although twice as many double marks were initiated using the more assertive RLU and FLU postures, this was expected overall, given the high rate of assertive posturing (59%) among dominant Wolves ($\chi^2 = 0.322$, df = 1, ns). Finally, is the second mark which completes the double mark, more likely to be from an assertive posture? Here, the data indicate a highly significant deviation from expectations ($\chi^2 = 13.90$, df = 1, $P < 0.001$). All but one of the second marks involved either RLU or FLU postures. The one exception was an RLU by the male followed by a SQU by the female. Males increased their use of RLUs from a base rate of 78% in other situations to 100% when completing a double mark, while females increased their use of FLU postures even more dramatically, from 32% overall to 89% in double marks.

Discussion

Several captive studies have found that dominant female Wolves are usually the initiators of double marks (93% of double marks, n=23, Rothman and Mech 1979; 64%, n=36, Mertl-Millhollen et al. 1986). In a sample of over 700 double marks by free-ranging Coyotes (*Canis latrans*), Gese and Ruff (1997) found that double marking was initiated by females 75% of the time. Unfortunately, none of the previous studies tested observed initiation rates against expected rates, based on the overall frequency of marking by individuals of each sex, as I have done here. However, the females observed by Mech (2006) did initiate double marking more often than expected, at a rate (63%) comparable to previous studies, so the lack of statistical significance for this result may be an artifact of small sample size. Thus it seems likely that double marks are more likely to begin as urinations by dominant females.

Mertl-Millhollen et al. (1986) found that 94% of double marks in their captive pack were initiated by RLUs (they combined RLUs and FLUs in their analyses). Unfortunately, although they indicate that RLUs comprised the majority of the marks they recorded, they do not present their data in a manner to allow testing of expected versus observed rates for the postures. In the present study, although the initial posture used in a double mark was most often an

assertive one (RLU or FLU), this is to be expected, given the relatively high rate of these postures in dominant individuals. This analysis suggests that the initial mark of a double mark occurs as an independent event, influenced by a combination of internal factors (arousal, hormones, urine load, etc.) and features of the environment (smells of old marks, food odors, conspicuous visual objects, etc.), but not with the deliberate intent to initiate a double mark sequence. For example, when Wolves are traveling, the lead Wolf is typically the initiator of double marks (Mech 1999); as it encounters sites which elicit its marking, the opportunity for double marking is then created for the trailing Wolf.

The second mark, however, is highly influenced by the presence of the first, and either its freshness, individual identity, chemical composition, or its mere presence at a specific location induces the second individual to use the more assertive RLU or FLU posture. Mertl-Millhollen et al. (1986) likewise found that all but one second mark was either an RLU or FLU; the one exception was a SQU (they combined SQUs and STUs) that followed another SQU. Thus the second mark of a double mark likely represents an increased level of arousal on the part of the marker. Whether that arousal represents generalized excitement, increased sexual motivation or increased aggressive (protective) motivation is not possible to determine here. A variety of hypotheses have been advanced to account for double marking: pair bonding, reproductive synchronization, mate guarding, and territorial defense being among the most common (Rothman and Mech 1979; Mertl-Millhollen et al. 1986; Gese and Ruff 1997). The tight relationship between the frequency of double marking and successful reproduction in Wolves (Rothman and Mech 1979; Asa et al. 1986; Mertl-Millhollen et al. 1986; Peterson et al. 2002) suggests that mating related functions, including mate guarding by the male, are most likely.

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Use of "Micro"-Corridors by Eastern Coyotes, *Canis latrans*, in a Heavily Urbanized Area: Implications for Ecosystem Management

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We document the use of very narrow, linear corridors (termed "micro-corridors") that facilitated movements by both a transient and a resident group of eastern Coyotes (*Canis latrans*) in a heavily urbanized area in north Boston, Massachusetts. Two corridors are discussed: one, a railroad line through downtown Boston; and two, a hole in a cemetery fence giving access to two separated cemeteries in a region of intense human development. Coyotes can be good subjects to illustrate the use of fragmented landscapes because they are common and thus are abundant enough to study yet are wary and avoid novel things and generally avoid people.

Key Words: Eastern Coyote, *Canis latrans*, corridor, fragmentation, Massachusetts, micro-corridor, urbanization.

The use of corridors is becoming increasingly recognized as an important conservation tool in fragmented landscapes (Beier 1995; Gilbert et al. 1998; Meffe and Carroll 1994). Corridors are strips of habitat connecting otherwise isolated habitat patches and have been promoted as important features of reserve design that allow movement among high(er) quality habitats (Meffe and Carroll 1994). Connecting landscapes rather than maintaining a large unfragmented core ecosystem is becoming the only alternative in many urbanized areas, especially where unregulated sprawl is occurring (e.g., Beier 1995). Yet, there is a paucity of data on animal use of corridors and how effective they are in connecting landscapes (Gilbert et al. 1998; Meffe and Carroll 1994). Because of the natural history of predators (e.g., large territories, long-distance movements), a knowledge of carnivore biology can predict minimum areas where ecosystems can function relatively naturally (Beier 1993; Gittleman et al. 2001; Mech and Boitani 2003; Meffe and Carroll 1994; Way et al. 2002a). However, the effectiveness (positive or negative) of corridors could greatly affect the size needed to maintain predators in certain sized refuges.

Coyotes are common in North America (Parker 1995), yet are elusive and difficult to capture (Way et al. 2002b); they are known to avoid novel objects and structures that are dangerous to them, such as box traps (Way et al. 2002b) or foothold traps (Conner et al. 1998; Sacks et al. 1999). Because Coyotes are ubiquitous (Parker 1995), neophobic and wary (Sequin et al. 2003), and have relatively large home ranges and movement rates (Way et al. 2004), they are a good species to use in the determination of corridor use, especially in urban areas. In other words, although they are common and frequently use human-dominated areas (Grinder and Krausman 2001; Way et al. 2004), they are naturally shy and avoid people by being nocturnal and traveling quickly in and out of human-dominated areas. For example, Way et al. (2004) found that Coyotes travel extensive distances on linear pathways such as powerlines, railroad tracks and golf courses in urbanized areas of Cape Cod, Massachusetts. Findings of Coyote use of corridors in highly urbanized and fragmented areas can potentially be used by managers to help protect more rare species and/or better design reserves for more common species. In this note, we describe the use of very narrow, linear (also called line corridors by Meffe and Carroll 1994) "micro"-corridors.

Study Area and Methods

Coyotes were captured for an ecological study on the north edge of Boston (42.43°N, 71.06°W), in eastern Massachusetts, in the bordering cities of Everett (4345.0 people/km^2), Malden (4290.5 people/km^2), and Revere (3089.0 people/km^2) (U.S. Census Bureau, 2000 estimates). Coyotes were captured by box trap (Way et al. 2002a) or by ground-based netlauncher (one coyote; Coda Enterprises, Mesa, Arizona) and outfitted with radio-collars (Mod-400, Telonics, Mesa, Arizona, USA and M1900, Advanced Telemetry Systems, Isanti, Minnesota, USA). Tracking protocols were described by Way et al. (2002a) and Way et al. (2004). Portable receivers (Custom Electronics, Urbana, Illinois, USA) and hand-held 3-element Yagi antennas were used to radio-track Coyotes both on foot and from a vehicle. Because of the highly developed landscape with many roads we mostly restricted our activities to automobiles as Coyotes did not react to them as much as to people (e.g., by running away; J. Way, unpublished data); occasionally we approached radio-collared Coyotes as close as possible on foot without disturbing them. We used binoculars and video-cameras when observing Coyotes, and city street lights, nightscopes, and occasionally headlights when following Coyotes at night with a vehicle (Way et al. 2002a; Way et al. 2004).

Observations

On 13 April 2004 we box-trap captured a dispersing 13.6 kg female Coyote ("Fog" – ID #BN0402) in a wooded section of Revere. Based on her behavior, she seemed to have been dispersing from the north to the south when she reached our study area. Her movements the week after capture were mostly to the south, including traveling >1 km through densely populated neighborhoods and streets. She localized in four different areas for 2-3 days each before moving to a new location. On 26 April 2004 we located her in a fenced-in abandoned field of ca. 4 ha behind a shopping mall at the north edge of the city limits of Boston. She reached that location by either swimming a 200 m river or traveling along railroad tracks over that same river. Based on data taken earlier that night we suspect that she went on the railroad tracks. For 3 days she remained in the fenced-in area and ate many Norway Rats (*Rattus norvegicus*) and Cottontail Rabbits (*Sylvilagus floridanus*) (J. Way, unpublished data).

On the night of 29 April she traveled 1.8 km southwest on the railroad line (which was bordered by industrial buildings on both sides), going under Interstate 93 and the Zakim Bridge, and entered an abandoned railroad yard in Boston where she spent the following day in a sparsely vegetated 200 × 50 m area. At 02:00 h on 30 April she followed the railroad tracks west through the Cambridge part of Boston and found the first wooded area available 4.9 km from her previous day's location. She was inactive through 23:37 h on 30 April 2004 and could not be located until 19 November 2004 when she was found alive 100.5 km south of her capture location (and 88.9 km south of her last location in Cambridge) in the town of Dartmouth, Massachusetts, near the Rhode Island border. To make that voyage Fog had to have crossed (over or under) six major interstate highways, including route 93 described above.

From 17 May 2004 to 3 April 2005 we monitored a pack of Coyotes ("The Cemetery Pack") in the bordering towns of Everett, Malden, and Revere. Four Coyotes were captured and radio-collared in this pack: one, "Maeve" (#BN0404), a 14.5 kg lactating female, captured 17 May 2004, was the breeding female; two, "Jet" (#BN0403), a 15.9 kg breeding male, captured by netlauncher on 29 June 2004, was Maeve's mate; three, "Jem" (#BN0406), a 10.0 kg 4.5-month-old pup, was captured on 26 August 2004; and four, "Cour" (#BN0405), a 12.3 kg 5-month-old pup, was captured on 15 September 2004. The pack consisted of two to three adults (i.e., one additional uncollared coyote was occasionally sighted in the pack's territory – its status was never determined but it was probably a helper Coyote [Way et al. 2002a] to Jet and Maeve) and four pups (two of which were not collared). The group went from six to seven members to four individuals by mid-winter 2004-2005 when it was presumed that some of the pack members (two of the pups [including Jem, last successfully located on 11 December 2004] and probably the uncollared adult) dispersed. The group resided almost exclusively in a green area (including some thicker woods) surrounding four large connected cemeteries. The entire area was about 2.5 km^2 (J. Way, unpublished data) and aside from inactive railroad tracks (i.e., no trains used them) the pack's territory was surrounded by high-density housing units and/or commercial spaces (malls) on all sides. Two roads transected their range, including a straight east–west road (Fuller Street) in the central part of their territory that connected the two cemeteries that they most frequently used.

Most of the cemeteries were surrounded by fencing consisting of vertical metal bars spaced 10 cm apart. The narrowness of this space prevented the Coyotes from crossing through the fence at random locations. However, a small corridor connected two cemeteries where a 34 cm opening occurred at a height of 55 cm in the south cemetery because of a missing metal post and two bent poles, one on each side. After crossing Fuller Street diagonally for about 15 m the Coyotes could then go through an open 305 cm × 198 cm gate (this door was never shut) followed by six steps that lead down into the north cemetery. Besides that crossing, there were two roads (one open to cars, the other gated) approximately 50 m east of the main corridor that the Coyotes could use (by diagonally crossing Fuller Street) to access either cemetery. There was one other opening (< 20 cm) in the south cemetery fence about 400 m west of the main corridor that led into a residential neighborhood (after crossing Fuller Street) bordering the west part of the north cemetery. Cour was the only coyote to use the road crossing corridor regularly and Maeve was the only one observed to use the neighborhood crossing corridor.

We radio-tracked the Coyotes six to seven days per week on average and, when tracking them at night (street lights illuminating the area), usually made sightings (range: one to ten sightings per night) from our parked, turned off vehicle of one to five Coyotes together crossing the main corridor (exceptions were during a heavy snowstorm [ca. 60 cm] when they did not use the south cemetery at all). They often also crossed the road in daylight during the early morning (06:00-08:00). During their first 6 months (i.e., April to October) sightings included some of the pups going under the fence (17 cm from fence to dirt) about 1 m west of the opening in the fence leading to the south cemetery, often during the same crossing (i.e., they were together) as other Coyotes went through the opening in the fence. This section of Fuller Street was straight, thus the Coyotes could see in both locations and we often watched them, especially the adults, standing on a hill in the south cemetery watching traffic and crossing when there were not any cars going by. Except for two instances when the Coyotes were almost hit by cars (the cars had to brake) all crossings were successful.

Monitoring of this group ended after the non-dispersing members (Maeve, Jet, Cour and one uncollared) were illegally poisoned.

Discussion

These data indicate that very small areas, if positioned in the right place, can be very important for Coyotes. These micro-corridors gave access to city habitats with few to no trees (along the railroad tracks) and also connected fragmented areas (cemeteries with fences) in already very urban landscapes. While not ideal habitat for Coyotes, these corridors were certainly better than nothing, and echoing the statement of Beier (1995: 235) when discussing Cougar (*Puma concolor*) dispersal, "any connection between two isolated patches is better than no connection." Managers can use these data for ≥3 purposes: one, to provide better habitat connectivity in already fragmented landscapes (e.g., opening sections of fence where wildlife is likely to cross); two, proactively establishing these types of corridors (ideally larger than described in this paper) where development is planned; and three, more regional planning where important habitat exists and maintaining linkages between separated core habitats.

The importance of sub-marginal habitats can not be overstated to facilitate animal movement. For example, Beier (1995) noted that Cougars can use corridors 100 m wide if the distance is < 800 m and 400 m wide if 1-7 km, yet adult Cougars have enormous home ranges in the hundreds of km^2 (Beier 1993, 1995). Likewise, species previously thought to inhabit only wilderness such as Wolves (*Canis lupus*) can often live at least at the edge of human-dominated areas if not persecuted (Mech and Boitani 2003) and no doubt corridors facilitate travel in and out of these landscapes. While preserving larger areas (e.g., Beier 1995) is preferred, this is not always possible in the real world and it is increasingly being discovered that animals are adaptable and can often respond to human-induced changes (e.g., Mech and Boitani 2003). Therefore, it is imperative to at least link what is remaining of our wild lands and this can start at the very specific micro-corridor landscape scale. For example, bridges that exist because of waterways (common in many cities) could also promote wildlife movement if cover and some space are provided.

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Bald Eagle, *Haliaeetus leucocephalus*, Preying on Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, on Cape Breton Island, Nova Scotia

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Olson, Storrs L. 2006. Bald Eagle, *Haliaeetus leucocephalus*, preying on Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, on Cape Breton Island, Nova Scotia. Canadian Field-Naturalist 120(4): 477.

At 1053 hours on 23 July 2006 a Bald Eagle, *Haliaeetus leucocephalus*, was observed in flight transporting in its talons a live Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, at South Harbour (46°52'01.7"N, 60°26'45.8"W), Cape Breton Island, Victoria County, Nova Scotia.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*, predator, Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, South Harbour, Cape Breton Island, Nova Scotia.

The Bald Eagle, *Haliaeetus leucocephalus*, is a large North American raptor that usually frequents aquatic environments where it feeds predominantly on captured or scavenged fish. Eagles may be seen daily in South Harbour, at the northern end of Cape Breton, Nova Scotia. This area appears to be occupied by a resident pair based on an observation of two adults seen standing very close together on a mud flat at the mouth of the harbour on 16 July 2006. South Harbour is a shallow, brackish, nearly landlocked estuary with an artificially maintained channel through the sandbar across its mouth providing exchange of water with the Atlantic Ocean.

On 23 July 2006 at 10:53 h, the screams of eagles drew my attention to two adult birds wheeling and skirmishing in the air over the southern shore of the harbour (46°52'01.7"N, 60°26'45.8"W). When two birds eventually flew directly overhead I saw that the lead bird was carrying a snake in its talons. The grayish-brown coloration and very attenuated, pointed tail writhing in characteristic ophidian fashion precluded any possibility of the prey being an American Eel (*Anguilla rostrata*). Two other witnesses (Johanna R. Humphrey, Katherine Allen) also confirmed that the prey, which was very much alive, was a snake. The individual carried by the eagle appeared to be somewhat in excess of 600 mm in total length. The only snake of this size in Nova Scotia would be a Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, females of which range from 412 to 916.9 mm, whereas males do not exceed 602 mm (Gilhen 1984). Because most of the area surrounding South Harbour, especially the southern shore, where the observation was made, is very heavily vegetated, the eagle most likely captured the snake while the latter was swimming across the surface of the water. Maritime Garter Snakes are "excellent swimmers" and have been seen on "freshwater lakes 100 metres or more from shore" (Gilhen 1984: 132).

The Bald Eagle feeds almost exclusively on vertebrates, paticularly on fish, followed by birds, and then mammals (Stalmaster 1987; Buehler 2000). Although Stalmaster (1987: 93) emphasized the eagle's "vast diversity of prey", he considered that snakes "are an unusual dietary item" (pages 95-96) and cited only the report of McEwan and Hirth (1980) of the remains of a single Black Swamp Snake, *Seminatrix pygaea*, in a nest in central Florida. Bald Eagles are notorious scavengers, and large numbers of snakes, including *Seminatrix*, are victims of vehicular traffic in central Florida (Smith and Dodd 2003), so there is a strong possibility that that food item was obtained as road kill. I have found no other references to Bald Eagles feeding on snakes, although they probably do so opportunistically wherever snakes and eagles occur together.

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Rat Poison Kills a Pack of Eastern Coyotes, *Canis latrans,* in an Urban Area

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Way, Jonathan G., Stephen M. Cifuni, David L. Eatough, and Eric G. Strauss. 2006. Rat poison kills a pack of eastern Coyotes, *Canis latrans*, in an urban area. Canadian Field-Naturalist 120(4): 478–480.

We document the death of a pack of Eastern Coyotes (*Canis latrans*) from high levels of brodifacoum, a second generation poison that is the active ingredient in some forms of rat poison (e.g., d-Con®). The Coyotes died within a week of each other during late March/early April 2005. This incident indicates the vulnerability of wild animals to commercial over-the-counter rodenticides.

Key Words: *Canis latrans* var., Eastern Coyote, anticoagulant, brodifacoum, poison, rat poison, Massachusetts.

Coyotes (*Canis latrans*) live successfully in a variety of habitats ranging from rural to urbanized areas (Gese et al. 1996; Harrison et al. 1991; Patterson and Messier 2001; Riley et al. 2003; Way et al. 2001, 2004). However, in almost all of these settings (except national parks; Gese et al. 1996) people constitute the major source of mortality for Coyotes usually via trapping, shooting and automobile strikes (Grinder and Krausman 2001; Parker 1995). Poison was historically used to kill predators but was banned in 1973 in the United States (Mech 2000; Mech and Boitani 2003). Mech (1970) noted that "poison is no doubt the most effective and efficient method of controlling or exterminating Wolves (*Canis lupus*)." However, the use of poisons is controversial because of their relative non-selectivity and reputation for inhumaneness (Cluff and Murray 1995). Most poisons, such as strychnine, cyanide, and sodium fluoroacetate (compound 1080), are not readily obtainable today. Because these poisons are illegal, many canid populations have greatly increased in the past 30 years (Mech and Boitani 2003; Parker 1995). Anticoagulants are present in urban areas (for rat control), and Riley et al. (2003) found them to be a significant cause of death for Coyotes in southern California. This paper details the poisoning deaths of a family group of Coyotes in urban north Boston, Massachusetts, most likely deliberately poisoned by someone .

Study Area and Methods

Coyotes were captured for an ecological study on the north edge of Boston (42.43°N, 71.06°W), in eastern Massachusetts, in the bordering cities of Everett (4345.0 people/km^2), Malden (4290.5 people/km^2), and Revere (3089.0 people/km^2) (U.S. Census Bureau, 2000 estimates). Box traps were used to capture Coyotes (Way et al. 2002a) except for one ("Jet") captured via a ground-based netlauncher (Coda Enterprises, Inc., Mesa, Arizona). Four Coyotes were radio-collared in this pack: "Maeve" (#BN0404), a 14.5 kg lactating female, captured 17 May 2004, was the breeding female; "Jet" (#BN0403), a 15.9 kg breeding male, captured 29 June 2004, was Maeve's mate; "Jem" (#BN0406), a 10.0 kg 4.5 month-old pup, was captured on 26 August 2004; and "Cour" (BN0405), a 12.3 kg 5 month-old pup, was captured on 15 September. The behavior of Maeve and Jet (i.e., frequently being located with each other and with the pups, including observations of them feeding the pups) indicated that they were the parents of these pups (see Way et al. 2001). The Coyote pack consisted of two to three adults (i.e., one additional uncollared Coyote occasionally sighted in the pack's territory – its status was never determined but it was probably a helper Coyote [see Way et al. 2002b] to Jet and Maeve) and four pups (two of which were not collared). The group was named the Cemetery Pack as it resided almost exclusively at one green area (including some thicker adjacent woods) surrounding four large connected cemeteries. The entire area was about 2.5 km^2 and on the north side, aside from unused railroad tracks the pack's territory was surrounded by high-density housing units and/or commercial spaces (malls) on all sides.

Results and Discussion

The group went from six or seven members in the fall of 2004 to four individuals by mid-winter 2004-2005 when it was presumed that some of the pack members (two of the pups [including Jem] and probably the uncollared adult) dispersed. Jem was last successfully located on 11 December 2004. Snow tracking and sighting data indicate that only one uncollared Coyote (a light yellowish-brown animal) remained along with the breeding pair and Cour. Similarly, Way et al. (2002b) found three to four individuals to be a

typical winter pack size of Coyotes in eastern Massachusetts.

The winter of 2004-2005 was harsh with much snow yet the Coyotes remained in their small territory. Residents often reported to us that they fed the Coyotes and people noticed some of the animals were collared (J. Way, unpublished data), indicating that the group obtained food from people living in and/or around the cemeteries. Aside from their abnormally small home range (see Way et al. 2002b), they behaved much like Coyotes studied in other locations, including the avoidance of people by being nocturnal (Way et al. 2004), crossing streets quite often, denning in wooded or relatively undisturbed (including under a gravestone) regions of their territory (Way et al. 2001), and acting territorial (Way et al. 2002b), including observations of Jet scent marking on the railroad tracks at the north edge of his pack's home range. There was no sign of the Coyotes' ill-health until just prior to them dying.

On 27 March 2005 Maeve was found dead in the middle of a cemetery in the central part of the pack's territory. She was an emaciated 12.7 kg despite appearing normal when sighted on 24 March. A gross necropsy revealed significant internal bleeding and no fetuses, indicating that she was not pregnant. A laboratory (Idexx Veterinary Services, www.vetconnect.com) diagnosis indicated erosive acute gastritis, severe necrotizing hemorrhagic endometritis with retained placental decidual tissue, and subacute suppurative endocarditis and myocarditis.

On 31 March 2005 Jet was found dead, 100 m from where Maeve died, and was also emaciated (14.3 kg). Radio-telemetry data indicates date of death was 30 March. He was observed moving normally 2-3 days before his death. Because of massive internal bleeding and similar gross necropsy results as Maeve, we only tested for poisoning (specifically for common chemicals found in household rat poisons) on Jet. Brodifacoum was detected in the liver at 0.733 parts per million (ppm), and the laboratory (Idexx) indicated that the results supported a diagnosis of brodifacoum poisoning.

On 3 April 2005 Cour was found dead in a shallow (< 1 m deep) canal that he frequently (i.e., daily) crossed prior to his death. He appeared healthy and weighed 17.3 kg, heavier than both of his parents. His relatively robust physique support observations from residents indicated that Cour (with a red ear tag) was the radio-collared Coyote most commonly seen eating food left by people. He was previously observed up-close and, besides limping on his right hind leg, appeared healthy on 1 April 2005. Not having obtained the results from Jet or Maeve at the time, we had a full necropsy performed at Tufts University (Grafton, Massachusetts). Internal bleeding (subcutaneous hemorrhage) was noted and based on autopsy findings and toxicological analysis of the liver (brodifacoum = 0.542 ppm), Cour died from an anticoagulant rodenticide. Because of the way Jet and Cour died, and the similar necropsy findings from Maeve (i.e., massive internal bleeding), we conclude that Maeve also died from brodifacoum poisoning.

Because all three of the Coyotes' behavior seemed normal prior to their death and that they all died close together (< 1 week), it appears that someone purposefully poisoned them at high concentrations rather than the coyotes having eaten enough poisoned prey to have died (i.e., from bioaccumulation; Riley et al. 2003). Most likely Maeve and Jet were poisoned around the same time, and then Cour was given a later dose(s) judging by a sighting of him traveling alone after Maeve and Jet were documented as dead. However, Cour's healthier condition might have allowed him to survive longer than his parents. We extensively searched for the source of the poisons (especially near where the coyotes died and where they spent the majority of their time when they were alive), including informally talking to numerous people, but we never managed to locate any substantial leads.

Throughout summer 2005 only a couple of sightings were made by residents and cemetery staff indicating that either the uncollared Coyote survived or, more likely, a new Coyote (i.e., formerly not part of this pack) dispersed into this location. Regardless of those individual sightings, this pack was decimated in a short period of time via rodenticides.

The public should be better informed of the dangers that common household poisons present for wildlife, especially in urbanized areas, and the potential health threat to humans and pets. For example, about two months later, pet dogs (*Canis familiaris*) died or were injured from rat poison in neighboring towns (S. Cifuni, personal communication). The slow, painful death of an animal internally bleeding is not pleasant and should not be acceptable in our society. These animals were diagnosed because they were part of an ecological study; due to the expense of testing and difficulty of finding non-radio-collared animals that die in the woods, it would be difficult to estimate how many non-target (i.e., not rats or mice) animals die from anticoagulants. We recommend that these poisons be strictly controlled either through making the over the counter sale of them illegal to all but licensed, professional exterminators and/or through required public education campaigns explaining the dangers of these poisons.

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capture of free-ranging Coyotes was approved by Boston College's Institutional Animal Care and Use Committee Protocol Number 01-02 (renewed in 2005) and by the Massachusetts Division of Fisheries and Wildlife permit #003.04LP.

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Way, J. G., I. M. Ortega, and **E. G. Strauss.** 2004. Movement and activity patterns of eastern coyotes in a coastal, suburban environment. Northeastern Naturalist 11: 237-254.

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A New Record of Deepwater Sculpin, *Myoxocephalus thompsonii,* in Northeastern Alberta

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Steinhilber, M., and D. A. Neely. 2006. A new record of Deepwater Sculpin, *Myoxocephalus thompsonii,* in northeastern Alberta. Canadian Field-Naturalist 120(4): 480–482.

We present the first documented records of Deepwater Sculpin, *Myoxocephalus thompsonii*, from northern Alberta, and the second record for the province. Three specimens of Deepwater Sculpin were taken in gill nets set at 17 to 20 m depth in Colin Lake, Alberta, on 15 September 2001. Colin Lake, located in the Canadian Shield region of northeastern Alberta about 125 km northeast of Fort Chipewyan, drains into Lake Athabasca via the Colin River. The only other known Alberta population of Deepwater Sculpin inhabits Upper Waterton Lake in the southwestern corner of the province. This record is approximately 300 km SSE of the nearest verified record in the Northwest Territories and 400 km NW of the nearest verified record in Saskatchewan.

Key Words: Deepwater Sculpin, *Myoxocephalus thompsonii*, distribution, Colin Lake, Alberta

Three individuals of Deepwater Sculpin, *Myoxocephalus thompsonii*, were collected in two separate gill net sets in Colin Lake, Alberta (59°34'N, 110°08'W) on 15 September 2001. One set was in 17 m of water, and fished for a period of 15 hours. The other was set at 18-20 m depth for 14 hours. Each net set consisted of one 60 m multi-mesh net with six 10 m panels ranging from 10 to 25 mm bar mesh and one 60 m net with six 10 m panels of 10 to 50 mm bar mesh. All nets were 1.8 m in depth. The two nets were fished in series on the bottom of the lake. Both collecting sites were located on the gently sloping periphery of the two deep basins in the lake (Figure 1). The maximum depth of the lake is approximately 25 m. The composition of the substrate at the sampling sites was not determined.

Species taken syntopically with the sculpins included Lake Whitefish (*Coregonus clupeaformis*), Cisco (*Coregonus artedi*), Burbot (*Lota lota*), Northern Pike

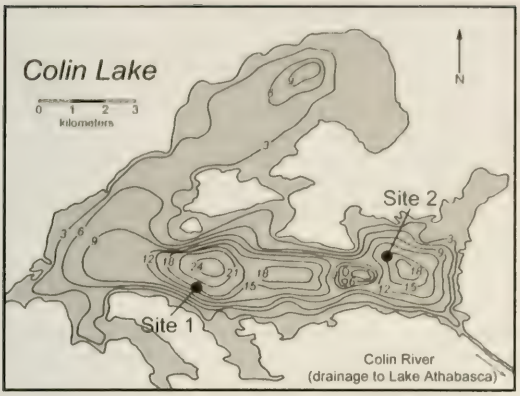

FIGURE 1. Bathymetric map of Colin Lake, with Deepwater Sculpin capture localities indicated. Depths given in metres.

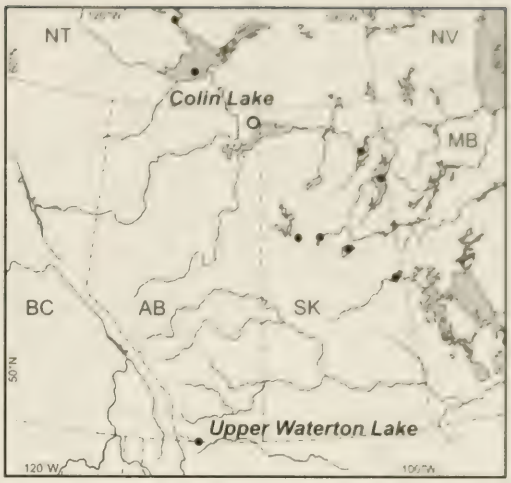

FIGURE 2. Distribution of Deepwater Sculpin in western Canada (data from Scott and Crossman 1973, and Murray et al. 2003). Colin Lake records indicated by open circle.

(*Esox lucius*), Lake Trout (*Salvelinus namaycush*), and Longnose Sucker (*Catostomus catostomus*). Lake Whitefish, Cisco, and Longnose Suckers were the most common species.

All three specimens of Deepwater Sculpin are gravid females, ranging from 62-74 mm SL (Standard Length), with four prominent, large, and straight preopercular spines, a large gap between the dorsal fins, and the gill covers free at the isthmus. Meristic counts of these specimens are consistent with data presented by McAllister (1961) for adjacent populations in Saskatchewan and the Northwest Territories. Dorsal fin spines were (number of specimens in parentheses) 7(2) or 8(1); dorsal fin rays 14(1), 16(1), or 17(1); anal fin rays 14(1), 15(1), or 17(1); pelvic rays 3(6); pectoral rays 16(2) or 17(4). Two of the three had an incomplete lateral line (ending under the last dorsal fin ray) with 32 pores; in the remaining specimen the lateral line continued posteriad to the caudal peduncle and had 36 pores.

These specimens represent the first record of Deepwater Sculpin from northern Alberta, and only the second record for the province (Roberts 1988). The only other known population in Alberta occupies Upper Waterton Lake (49°02'N, 113°54'W) on the Alberta/Montana border (McAllister and Ward 1972) (Figure 2). Nelson and Paetz (1992) suggested the likely presence of Deepwater Sculpin in northeastern Alberta, given the proximity of populations in adjacent Saskatchewan and the Northwest Territories. The closest populations supported by voucher specimens are Great Slave Lake, Northwest Territories (~300 km NNW) and Wollaston (400 km SE) and Reindeer Lakes (520 km SE), Saskatchewan (COSEWIC 2006*). Records from Lake Athabasca in northwestern Saskatchewan (~100 km ESE, COSEWIC 2006*) are not supported by voucher specimens. The specimens from Colin Lake fill this gap, and further suggest that additional populations of this enigmatic cottid remain undiscovered in the northern portions of its range. New populations continue to be discovered as deepwater habitats are systematically sampled (i.e., Murray et al. 2003; COSEWIC 2006*).

Although typically encountered at depths greater than 44 m (Scott and Crossman 1973), this species is occasionally found at much shallower depths, especially as larvae and juveniles (COSWEIC 2006*); Rawson (1951) collected specimens in 1 m of water in Great Slave Lake, while McPhail and Lindsey (1970) documented specimens from 4-6 m in Great Bear Lake. Alex Peden (*in* McPhail and Lindsey 1970) suggested that this fish is probably concentrated in deep water during the summer and moves inshore in the fall. The discovery of Deepwater Sculpin in Colin Lake is thus somewhat unusual in that the lake is not particularly deep, with a maximum depth of only 25 m. Further studies to determine seasonal distribution patterns within the lake and any unique biological characteristics of this population would be valuable. It is worth noting that Colin Lake is connected via the Colin River to the Saskatchewan side of Lake Athabasca (approximately 20 km to the SE) where depths can reach 124 m. It is likely that trapping efforts in deepwater habitats of Lake Athabasca will provide additional records. However, there are currently no data to support the use of the Colin River as a post-glacial movement corridor between Colin Lake and Lake Athabasca.

The only populations of Deepwater Sculpin currently given protective status in Canada are the Great Lakes – Western St. Lawrence populations, which were listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada [COSEWIC] (Parker 1988) but have recently been downgraded to Special Concern (COSEWIC 2006*), and are on schedule 2 of

the Canadian Species At Risk Act (SARA). Western populations (which include the new population discussed herein) were designated Not at Risk in 2006 (COSEWIC 2006*).

The gill nets used to capture these Deepwater Sculpins were deployed as part of a Shortjaw Cisco (*Coregonus zenithicus*) survey in the Canadian Shield region of Alberta (Steinhilber 2004*). Our recent experience suggests that deployment of cyalume light stick-baited wire minnow traps in deepwater habitats is more effective at sampling Deepwater Sculpin than are small-mesh gill nets. The effectiveness of this technique has not been previously discussed in the literature. Long-term surveys of Lake Saganaga on the Ontario/Minnesota border have primarily used small-mesh gill nets (Etnier and Skelton 2003). Between 1986 and 2003, only one specimen of *M. thompsonii* was taken. Use of light stick-baited cylindrical wire minnow traps during summer 2004 per our request resulted in capture of 10 specimens (D. A. Etnier, personal communication). Similarly, during 2003 we provided Fisheries and Oceans Canada personnel on Lake Nipigon with light sticks and traps that were set simultaneously with their gill nets, with similar results (A. Van Ogtrop, personal communication). Other researchers working on Deepwater Sculpins have had similar experiences (T. Sheldon, personal communication; COSEWIC 2006*). We thus strongly recommend the use of this technique over small-mesh gill nets for assessing presence/absence of Deepwater Sculpin.

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We thank B. Meagher for field assistance. Collecting was conducted under permit 401 FR issued to M. Steinhilber. D. Neely was supported by a grant from the British Columbia Ministry of Fisheries.

Materials Examined

All specimens are deposited in the holdings of the Royal Alberta Museum, Edmonton. PMA L01.33.319, *Myoxocephalus thompsonii*, *n*=1 (74.0 mm SL), Colin Lake, 59°33'12"N, 110°9'30" W. 15 September 2001. Collectors: M. Steinhilber, B. Meagher. PMA L01. 33.311, *M. thompsonii*, *n*=2 (62.7-73.0 mm SL), Colin Lake, 59°33'28"N, 110°5'8" W. 15 September 2001. Collectors: M. Steinhilber, B. Meagher.

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Book Reviews

ZOOLOGY

The Clements Checklist of Birds of the World 6th Edition

By James F. Clements. 2007. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850 USA. 864 pages. U.S.$59.95. Cloth.

If you travel outside of North America [or any other home territory] you will have to face *the* question. Is this bird species one I have seen before? There are so many look alike birds that are different species in some areas and the same species in others. You can wonder about crows, oystercatchers, stilts and the plethora of wagtails. Or is this bird with the same or a similar name to a look-alike home species, the same or a different bird. For example are Willow Grouse, Red Grouse and Willow Ptarmigan the same species? It can be really confusing.

Enter Dr. James Franklin Clements [1927-2005], an orphan who served in the U.S. merchant marine and navy before going to college. In the Korean war he was in the air force, before finally settling to get his Ph.D. in 1975. His thesis became the first edition of a check list of the world's birds. Because of ever-evolving taxonomy we are now at the 6th edition.

Clements has produced a list, simply a list, of all the known bird species and subspecies. Producing such a simple list is a very complex task indeed. It must have felt like trying to resolve the unresolvable on many occasions. So here we have this simple list and can ask how useful is it? Theoretically, I should be able to check out a bird that I am unsure about. Looking it up in Clements should allow me to clarify the bird's status and decide whether it can be added to my life list or not.

How well does this work? The first problem is you must use the same English name as Clements. Nowhere is there a list of alternative names. If you look for Melba Finch in the index you will be disappointed. You will need to use either Green-winged Pytilia or look for the genus *Pytilia.* The North American bias is shown by *Circus cyaneus* being called Northern Harrier as opposed to Hen Harrier [the older name].

Now we come to the sticky issue of splits and lumps. The North American Magpie is split from its European counterpart, as is Hooded and Carrion Crow. Clements lists the Somali Ostrich as a subspecies, *Struthio camelus molybdophanes*, whereas most recent literature gives this distinctive blue-necked bird separate species status [*Struthio molybdophanes*]. Similarly the brightly coloured barn swallow found only in the Nile delta is not split from its more common cousin. Again this is listed by some as a separate species. Egyptian Swallow, *Hirundo savignii*. The *vegae* Herring Gull is separated as East Siberian Gull. This is open to question and recent work suggests more research is needed. Certainly I have found it difficult to see a difference in the field. Is it a little darker than a Herring or was I being deluded by poor light?

Each entry is accompanied by a description of the species range. These ranges are useful when comparing species. For example, my list for Mongolia includes Pink-footed Goose, *Anser fabalis*. The range for Pink-footed Goose in Clements does not include Mongolia, whereas the Bean Goose, correctly *Anser fabalis*, is present. Clearly this is an error in the Mongolian list, probably due to translation problems, that was quickly resolved.

However, the ranges given for other species are less useful. Clements can be forgiven for minor lapses such as the range of the Northern Wheatear or Crested Auklet – given as Siberia. The birds I saw on the eastern-most coast of Russia this year were technically in the Russian Far East – not Siberia. Siberia does not extend to the east coast. This is minor compared to Houboura and Macqueens Bustards. Clements splits these two birds and gives Macqueens a range of the Nile to .... Pakistan. *The Handbook of the Birds of the World*, Volume 3, cited as the major reference, does not split this species but lists it as a subspecies, *Chlamydotis undulata macqueenii*, and correctly gives the range as NW Kazakhstan to .... Mongolia and Northern China. Similarly Clements does not mention the range extension of Cardinal and House Finch into eastern Canada.

I have checked to see if some of the recent discoveries are included in this check list. Scarlet-banded Barbet and Long-whiskered Owlet are, but the two most recent discoveries, Large-billed Warbler [the 1867 reference is given but not the recent March 2007 capture of two birds] and Gorgeted Puffleg, [May 2007] are not.

Having one coherent checklist is extremely valuable for the travelling birder. It still does not solve all the issues with a changing taxonomy, but at least you can use it as a solid foundation for your records. You will still have to research current taxonomy and recent discoveries and decide which birds you will accept as a full species.

Incidentally, I make it a point never to directly mark books. I use post-it notes or equivalent. I will make an exception for this one book. Not only is it set up to be

ticked, but it is a good idea to add information on species as new data become available. That is until version seven is printed.

ROY JOHN

2193 Emard Crescent, Beacon Hill North, Ottawa, Ontario K1J 6K5 Canada

Birds of Europe, Russia, China and Japan: Passerines, Tyrant Flycatchers to Buntings

By Norman Arlott. 2007. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 240 pages. U.S.$29.95. Paper.

My wife and I recently decided to visit northern China and Mongolia [the Silk Road]. This left me with a dilemma; which bird book or books would I need to take to get adequate coverage. I did not want to pay $100 or more for a paperback copy of *A Field Guide to the Birds of China* (John MacKinnon and Karen Phillips, Oxford University Press, New York). My *Birds of Russia* (Flint et al.) gives fair coverage but the illustrations are not as precise as I would like them, particularly for warblers, etc. *Birds of China* (De Schauensee) only illustrates some of the species and gives descriptions of range only and you need a thorough knowledge of China's geography to follow these descriptions. *Birds of India* (Grimmett et al.) is a much better guide with a lot of species covered [as winter visitors], but the coverage is far to the south so the range maps are useless.

Then Princeton announced *Birds of Europe, Russia, China and Japan* and I thought it would be just right for my purposes. While the book covers only the passerines (from Tyrant Flycatchers to Buntings), it is exactly these groups for which I needed a better, more up-to-date book. The non-passerines, like ducks and gulls, tend to be more distinctive and are suitably covered in previous books.

Technically Princeton calls this book an illustrated checklist. Each species has an illustration or two with very brief facing-page text. At the back of the book are range maps. While the text presents little about each species but key features, it is perfect for the traveller. It measures only 5" × 7" × ½" [12.5 × 17.5 × 2 cm] and weighs 14 oz [100 g or around half a normal field guide].

The range maps are 2" × ⅞" [5 × 2 cm] and cover from Britain to Kamchatka, from Svalbard to Northern India. As there are no country boundaries [these would make the little map too cluttered] I found it helpful to create a mask with a piece of clear plastic sheet. I traced the outline of the map in blue, then, using Google Earth as a guide [Google Earth has a similar orientation to these maps] I shaded in transparent yellow the region I plan to visit. I can now place the mask over each map and quickly see if I will be in any bird's range. This was somewhat satisfactory. I compared my list created with the mask to actual trip lists and I was in error by around 15 percent.

Although the book's title suggests it covers Europe, Russia, China and Japan, the maps go much further. For example it includes the Nile Valley Sunbird of the Middle East and the Purple Sunbird of India, as well as the geographically restricted Sinai Rosefinch and Sub-Sahara's Blandford's Lark. I am not sure of the author's rationale for including birds like the Rosy-patched Shrike, a purely African species [but I am happy he did so].

The critical illustrations are those of difficult to identify birds such as warblers and some finches. Arlott has been illustrating bird books for many years [my first Arlott book is over 40 years old]. His skill has grown dramatically and his most recent work is top quality. My copy has all the illustrated species looking a little dark. [Technically the hue is correct but the illustrations are over saturated and this is part of the printer's quality control. North American readers will see this when looking at the Cedar Waxwing and Varied Thrush illustrations. Both are way more intense than the real birds I have seen this year.] In detail though the artwork is excellent. When I looked at Arctic Warbler and try to separate it from it congener leaf warblers or the Beautiful Rosefinch from its relatives then the relevant field marks are apparent. North Americans will have no difficulty identifying wood warblers using this guide, even with the intense colours. [I was surprised to find over 40 "North American" species, such as Wood Warblers and Icterids, have been seen in this region as vagrants.]

This book solved my problem and will be ideal for other travelers to this large region. I look forward to a similar book on the non-passerines. I hope Princeton does well with their checklist series [I believe they have a dozen titles] as they are so much more convenient when luggage weight is critical.

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Deep Alberta. Fossil Facts and Dinosaur Digs

By John Acorn. 2007. The Royal Tyrrell Museum and The University of Alberta Press, Edmonton, Alberta Canada. XII + 186 pages. $26.95.

Early on the recognition of our country's rich resources was often a reactive response, rather than proactive endeavours. It was in response to the U.S. activities, primarily those of Barnum Brown (1873–1963) of the American Museum of Natural History, New York, that the Canadian government in early the 20th century began their vertebrate paleontological activities in the Canadian west. First under the Geological Survey of Canada, followed by the National Museum of Canada (now, Canadian Museum of Nature, Ottawa). These activities were central to what has been called "The Great Canadian Dinosaur Rush" (see David Spalding's *Into the Dinosaurs' Graveyard*, Doubleday Canada, Toronto, 1999).

Despite these efforts, and the bountiful treasures collected and studied, it wasn't until the late 1960s that the Province of Alberta, host of the majority of these activities, was able to begin to take control of its own paleontological resources. Provincialism – restriction of outside exploitation – emerged. This occurred with the materialization of the University of Alberta, Edmonton, establishing its own paleontological program of education and research, supported by the *Vertebrate Paleontology In Alberta* conference in 1963 (University of Alberta, 1965) in addition to the establishment of the Provincial Museum of Alberta (Edmonton), which opened in 1967. What followed was a slow eruption of discovery, research, tourism and marketing savvy. John Acorn's *Deep Alberta* skims the surface of all that is sexy in paleontology in Alberta. And as most will see, there is a lot to witness.

Acorn's guide, based on his CKUA radio series by the same name, is not quite similar to the other popular guides to Alberta's paleontological wealth, *The Land Before Us, The Making of Ancient Alberta* by the Royal Tyrrell Museum of Palaeontology (Lone Pine Press, Edmonton, 1994) is more of a complement to its own gallery (somewhat similar to the Royal Saskatchewan Museum's Earth Sciences gallery guide, *Geological History of Saskatchewan* by John E. Storer (Government of Saskatchewan, Regina, 1989)). Nor is it obviously as in-depth as *Dinosaur Provincial Park* (edited by P. J. Currie, Indiana University Press, Bloomington, 2005), a symposium volume summarizing all the major taxonomic groups found within the park. *Deep Alberta* is designed similar to a field-guide, with one-page descriptions and colorful illustrations of species, or non-taxonomic themes.

Alphabetical in its listings of themes, creatures, and places, each item listed is given usually a page of text, accompanied by a full page illustration, often a photograph of an exhibit at the Royal Tyrrell Museum of Palaeontology. These range from mosasaurs, those snake/lizard derivatives from the marine environment of the Cretaceous Period, the *Chasmosaurus*, the horned-dinosaur familiar to the fields of Dinosaur Provincial Park, to the singularly rare *Atrociraptor*, the "savage robber" skull found near Drumheller – only one partial skull of this is known.

Of place, from the badlands near Drumheller to the Milk River regions are few. The thematic questions include "How do you Know Where to Dig?", an often made public query. Yet, surprisingly, a hot topic like extinction is not addressed. Of people, the likes of Barnum Brown and the Sternberg family (three generations of which have worked in Alberta) are briefly brought to the fore. Appended is a list of most of the Ph.D.'s who are currently at play in the paleontological field of Alberta. Those who have contributed research but lack graduate documentation, or who have provided discoveries without institutional support, are not recognized in this summation.

Since the discovery by Joseph B. Tyrrell (1858–1957) over a century ago of an *Albertosaurus* jaw, later culminating with erection of a provincial museum specifically dedicated to paleontology (The Royal Tyrrell Museum of Palaeontology) and the designation of Dinosaur Provincial Park as a World Heritage Site, the Province of Alberta has ample reason to show off its fossil resources. Acorn's *Deep Alberta* is a primer of a primer, a very first introduction to this wealth. Acorn has much to choose from in his summation of paleontology of Alberta and will likely be another useful marketing tool to maintain the visibility of this science in the minds of the public. The treatment of these resources by other provincial jurisdictions should take note. Alberta is not the sole place for paleontology. There is a lot more to see.

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Gibson's Guide to Bird Watching & Conservation

By Merritt Gibson. 2007. Nimbus Publishing Limited, Halifax, Nova Scotia, Canada. 214 pages. $16.46.

This small bird watching guide to the maritime provinces is a tribute to the birds of Nova Scotia, Prince Edward Island and New Brunswick. It is also a tribute to the ornithologists and bird-watchers of the area, the unsung heroes who for the past several decades have been the backbone of bird conservation and study to preserve habitat, protect endangered species and pro-

mote birding. The reader is introduced to a variety of birds and a variety of birders following the colourful pages of anecdotes, life histories and illustrated birds.

The book does not try to describe all of the birds which regularly visit the maritime provinces of Canada. It is not a field guide to all birds. It is a book for bird-watchers and conservationists and introduces the reader to several birds, each of the sea, the coast, the shore, freshwater, the forest, agricultural lands, and finally towns and gardens, in that order. The book is divided into the seven sections named above with an introduction to each section and ending comment introducing birders amateur and professional studying within each of the sections and involved in the stewardship of habitat. Three to seven birds are described in some detail in each section. The description includes anecdotal stories of the birds, their habitats, origins of their common name, behaviour, nesting and egg-laying behaviours and chick hatching and rearing behaviour. Whether one is ready to brave the wind and waves to spot birds, or maybe just sit in an armchair by the window, the text leads you to appreciate the diversity of birds present in the Maritime Provinces and the possibilities of discovering or re-acquaintance with species which have always been present and probably have been visible many times.

Conservation is one important focus of the book and the end of each chapter gives some detail on the work of amateurs and professionals who research, monitor, and care for the different populations of each bird species mentioned. Throughout Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland, many different bird populations are in decline, especially but not exclusively, species mentioned in the book. Different programs are in place to monitor and conserve lands inhabited by these birds, and programs are being developed to make the public aware of the trends in bird populations. This book is one of those awareness projects.

I read the book quickly and then went back over the chapters more slowly to savour the stories of birds I know and the birds mentioned which I would like to see one day. It is an exciting book for a part-time birder and one which taught me not just about the birds but even more about the state of the shoreline, the wetlands, the forests and the agricultural fields. To the visitor, the land changes little, but to the resident, there are problems and potential solutions. The solution is often awareness and information. I applaud the researchers for their work and Merritt Gibson for bringing it together. The book also serves as a delightful picture book illustrated by Twilia Robar-DeCoste with drawings of birds, birds in their natural settings, landscapes and seascapes to show perspective and the beauty involved in the study and enjoyment of birding on Canada's East Coast.

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Ladybugs of Alberta: Finding the Spots and Connecting the Dots

By John Acorn. 2007. University of Alberta Press, Edmonton, Alberta, Canada. 169 pages. $29.95.

This is an important book about insects for naturalists. It has field credibility. Acorn reviewed and understands the writings of the experts on lady beetle identification and ecology in North America. Acorn studied the specimens that collectors in Alberta deposited in collections. But most importantly, he was in the field in Alberta chasing and watching and photographing lady beetles. The result is a guide, written by an expert, which will be valuable before someone starts chasing lady beetles and will continue to provide insights as a person's expertise grows. And it is accessible; virtually anyone will be able to use it.

What can you do with this book? First and foremost it is possible to identify the lady beetles (a.k.a. ladybugs, ladybird beetles, Coccinellidae) that live in Alberta. The combination of excellent colour drawings, photographs, plus key features highlighted in text make it possible. In addition the range maps, both range in Alberta and much of North America, notes on food and habitat preferences give some guidance, to reduce the probability of an embarrassing misidentification. The difficult identifications are not glossed over. The necessity of dissecting genitalia to distinguish some *Hippodamia* (e.g., *glacialis* and *quinquesignata*) and the significance of chromosomal differences between *Chilocorus stigma* and *C. hexacyclus* are covered clearly, with humour and insight.

Most authors would have taken the easy route and restricted themselves to the big showy lady beetles with which most naturalists are familiar. However Acorn tackled the "lesser ladybugs", a daunting task to make what is known about *Scymnus* and *Hyperaspis* and *Brumoides* widely available, including both features that make species level identifications possible and some natural history. Acorn deserves credit for persevering and including the lesser species, especially considering the extra work, almost double the number of species, and that they are not as charismatic to general naturalists and that little is known about them. He engenders interest in these little beetles.

In addition to identification and species accounts, there are substantial sections on ecology, behaviour, and history of coccinellid study in Alberta. The hot topic of the influence of introduced species on native species is attacked head on. It starts with a perceptive critique of the functionally useless Nature Canada attempt to coordinate a citizen science project on lady beetles in the 1990s. His says that a prejudgment, introduced species are bad, led to many of the problems. In my view, the other key problem was that there was little or no quality control that compromised the value

of the data. What was needed was Acorn's book, or listening to field entomologists, during the planning process. The discussion continues with an assessment of the Evans' hypothesis that native species have constricted their range to ancestral habitats, that is have become less common in extensively human altered habitats (farmland and suburbia) after the arrival of introduced species such as the seven-spotted lady beetle. Refreshingly, he is able to present his own data to support his views. His views about ecological change, conservation and invasion biology are clear, logical and worthy of discussion.

The style deserves special mention. It is highly credible, yet at the same time there is a breath of whimsy and fireside chattiness. A fine example is the description of taste-testing. You will not look at a brightly coloured lady beetle the same after you read this.

What bothered me during my initial readings? The first was that I wanted more detail, more data. But, this is a book for generalists and not the appropriate place for the level of detail I want. Second were those couplets. Each species account includes a quirky, rhyming couplet. I did not understand many at first, but they did grow on me. Perhaps they are like beer, an acquired taste. Third were the common names. The Entomological Society of Canada is working to provide consistent, standard common names for insects, just like we have for birds. However, many were ignored, for example *Mulsantina picta* here is the Painted Ladybug, not pine lady beetle. However, some of the newly coined names hit the nail on the head and deserve to be maintained. My favourite was the Once-squashed Ladybug, a cryptic species in the same genus as the Twice-stabbed Ladybug. Yes, it needs to be squashed on a microscope slide to examine its chromosomes in order to be identified. Brilliant. These are minor complaints. The identification sections are worth the whole price of the book. The discussion of introduced species is worth the whole price of the book. The description of how to taste a ladybug to assess its palatability is worth the whole price of the book.

Our understanding of foods, habitat use and phenology (seasonal activity) is not as well developed in North America as it is in Great Britain and Europe. People armed with this guide, will have the tools to be at the forefront in remedying this situation. Compilations often function as a catalyst for a quantum leap in interest and new findings by curious naturalists. I predict this book will provide another great example in western Canada.

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A New World of Animals: Early Modern Europeans on the Creatures of Iberian America

By Miguel de Asua and Roger French. 2005. Ashgate Publishing Ltd., Aldershot, England. 235 pages. $89.95

How would you describe a beaver to someone who has never seen a beaver? Is it simply a 20 kg rat with thick fur and with something that has the texture and consistency of an elephant's ear sticking out of its backside? That person to whom you are giving the description might be forgiven for disbelieving you. What about a whole forest of new animals including muskrats, otters, woodchucks, skunks and any of the larger forest-dwelling species? In North America we have an abundance of animals which were unknown in the Old World before European exploration. Combine these animals with their South American counterparts and add birds, reptiles, amphibians, and insects known only to the New World and you have the basis for the book given to us from Miguel de Asua.

For the history buff and the technophile who wants to track down the classic literature of the conquest of the Americas, this book is a new door to obscure literature of natural history. Miguel de Asua is an Argentinian professor at the Universidad Nacional de San Martin and Roger French was English, from the department of History and Philosophy of Science at Cambridge University, UK. Their work focuses on the animals found by early explorers of the Americas, particularly South America though reference is made to animals occurring in North America as well. The reader is introduced to many of the early writers describing the newly discovered lands, and emphasis is placed on the animals, birds, reptiles, amphibians and insects which the authors noted at the time.

From the earliest explorers, Columbus and his followers, the discovery of the New World has been a discovery of the beauty and ferocity of many new and exciting creatures. Columbus returned with birds, skins and many stories trying to describe the richness of nature which he found and impress his audiences with tales of strange and exciting beasts. Written accounts which survived from his time sought to identify the animals, birds and reptiles using the experience of known animals and the descriptions are interesting associations with European and Asian animal forms put together to construct forms which would be within the experience of the audience. So bison looked like camels or cows, armadillos looked like striped foxes and manatees looked like large puppies.

For two hundred years the animals of the New World were exotic, unique and objects of wonder in Europe. Even as the years rolled on with more and more literature being accumulated from explorers, naturalists and then colonists with animals imported into Europe as exotic pets and zoo specimens, the earliest descriptions survived and were repeated. De Asua takes us on a literature search, naming writers, quoting their writ-

ings and showing the parallels as information, disinformation and wild speculation was accumulated, repeated and refuted.

This is a new study of scientific literature because of its origins and perspectives. First of all it is centred on South America with only some brief mentions of North American mammals. Secondly it is restricted to the writers first in Spanish then in central Europe, all of whom wrote in their own language for audiences in their local areas. Only toward the end of the literature covered in the book are we introduced to English sources though the names are obscure here as well. A good conclusion is added where the ideas of the sailors, soldiers, functionaries, friars and adventurers each had their day and their utility in telling a part of the natural history story. The opinions and wisdom of the native peoples of the Americas are not given much consideration because of course they did not write to Europe and the conquerors formed their own opinions based on the utility of the natural wildlife to their own needs, not the inherent worth of the ages of native wisdom.

This is neither an easy book to read nor a simple historical storybook. It is a history of intellectual thought and discovery. There are many gems of thought included but the reader needs to be attentive to the thesis of the writer not simply to the many repetitions of the details.

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Penguins of the World

By Wayne Lynch. 2007. Firefly Books, 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 175 pages. U.S.$24.95. Paper.

If you take one of the most photogenic birds in the world, living in the most pristine habitat and send forth a remarkable photographer, can you fail? No!

The hard part about penguins is getting to where they live. Then anyone can point- and-shoot and get a fine photo. The appearance of penguins is so charming that failure is not an option. A quick thumb through the photos in this book will show how Lynch can take such a good photo opportunity and make the result magnificent.

But let us look at the text first. In a smooth flowing narrative the author takes us through the lives of the world's 17 penguin species. He covers the origins and ancestry of this long-lived family. Most intriguing is Lynch's description of a five foot seven inch prehistoric bird. Now that would have been a sight! The author explains why penguins are shaped the way they are and the uniqueness of their adaptation to sea life. He describes their habitat. You may be surprised to realise that most species live in the temperate [not polar] region. With humour, he explains their sex lives and the advantages of their marriage and divorce systems. He follows their lives from egg to adulthood. In all of this he make these birds sound human. Or is it that we humans are like penguins – after all they have a much longer lineage?

From sex to family life, from feeding to predators the author weaves a delightful tale of the delightful creatures. In addition you will get to know some of the penguins, sometimes less-than-delightful, neighbours. Only a photographer as good as Lynch could make a pair of Sheathbills look cuddly. He also adds a chapter on the northern counterpart of penguins, the alcids.

An appendix lists all the penguin species, with a range map and photo for each one. This is not a field guide as there is no species description. There is, however, a small photo of an adult. The range maps and distribution notes are clear and useful. Lynch notes the population size and the species status. These range from a scant 1000 or more pairs of Galapagos Penguins to 10 million Macaronis.

The photographs are wonderful. Many of them are so balanced in format as to look posed. This speaks of the infinite patience and possibly some good luck that Lynch had on his trips. One notable point is the sunshine. In my trips to polar regions I rarely see the sun, yet many of his photos bask in glorious light – more patience I think. There is a photo of a braying penguin showing the backward-facing spikes on his tongue in remarkable detail. There are numerous portraits of chicks, with and without parents, that are irresistibly charming.

I have seen 10 out of the 17 living species. To see six of the remaining species I must visit New Zealand and the islands that lie to its south, a difficult and very expensive area to reach. But the lure for a penguinophile is undeniably very strong. However, if you have never seen wild penguins and are not likely to do so, then this book is the next best thing. Buy it and enjoy it, for only the smell is missing.

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Raptors of Western North America and Raptors of Eastern North America

By Brian K. Wheeler. Princeton University Press, Princeton, 41 William Street, Princeton, New Jersey 08540 USA. Hardcover. 544 pages and 430 pages, respectively. U.S.$29.95.

The hardcover editions of these two volumes were reviewed in Canadian Field-Naturalist 118(1): 142-143 by Houston and John. These books have now been issued as paperbacks, reducing their cost [U.S. $49.50 Cloth] and weight. There are no updates or additions.

ROY JOHN

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The Sand Wasps: Natural History and Behavior

By Howard E. Evans and Kevin M. O'Neill. 2007. Harvard University Press. Cambridge, Massachusetts, USA. 340 pages. U.S.$49.95 Cloth.

As a baby-boomer "bugster", two writers had a tremendous effect on my early enthusiasm for insects: Edwin Way Teale and Howard Ensign Evans. Sadly, both have passed on, but their legacies live on, and it was with pleasure that I agreed to review a book on the sand wasps (the subfamily Bembicinae of what is now the family Crabronidae, formerly included in the Sphecidae) coauthored by Evans, and created from his notes, ably revised and updated by his former student and colleague Kevin O'Neill.

As one might expect, this is indeed a book for specialists. However, it is also clearly written, and a model for studies of how comparative natural history and behaviour can be informed by phylogeny and brought together in a synthetic fashion. If you have read *Wasp Farm*, Evans' 1963 classic of popular science writing, you understand what this is all about. If not, the first two paragraphs of the introduction to *Sand Wasps* provide a concise, if not downright brilliant, justification for this sort of work. Later, on page 5 in the section on "Sand Wasp Natural History/Sand Wasp Science" the authors provide a very fine defense of natural history in general. The overall purpose of the book is to update Evans' previous works on the sand wasps, and it's clear that to appreciate all of the details of the present volume, one really should have read the works that preceded it. But having skipped that step, I still found the book a pleasant and interesting read.

The book begins by putting the sand wasps in context, both with respect to their biology and their classification. After that, chapter-length summaries are provided of what is known about the wasps, on a tribe-by-tribe basis. I found myself getting a bit bogged down in details during Chapters 2-7, but a student of sand wasp biology would find them riveting, I'm sure. My only criticism of this part of the book, which lays out the evidence to be synthesized in the remaining chapters, is that no summary is provided of the classification used, to which one could refer back while working through the tribal accounts. I also found myself wishing for a gallery of illustrations, showing the various genera of sand wasps side by side. For general readers from eastern North America, the most useful portion of these chapters will probably be the account of cicada killer wasp biology (genus *Sphecius*), in Chapter 3.

The synthetic portion of the book begins in Chapter 8, "Comparative Ethology of Sand Wasps." Patterns begin to emerge, but so does an overall impression of great diversity, tremendous complexity, and many unanswered questions. The theme of phylogenetic reconstruction enters strongly at about page 260, at which point I became quite nostalgic, since this was always my favourite aspect of Evans-school wasp studies in the past. I found myself wishing that I were reading an updated account of the evolution of all solitary wasp behaviour, not just that of one subfamily, but the focus here is clearly on the sand wasps alone. My interest was strongly piqued again, however, by the section on sand wasp conservation. The preservation and promotion of open, erosional habitats is becoming increasingly important to those of us who study organisms that require such places (yes, I'm thinking here of tiger beetles), and it is encouraging that sand wasp biology adds further impetus to this cause.

As a work of entomology, this book is superb. I doubt many people outside the hymenopterists' guild will read it cover to cover, but I do think that various portions of the text have important implications for evolutionary biology, entomology, natural history, and conservation biology. And as a final offering from one of the great naturalists of the last century, it is a welcome book indeed.

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Tracks

By D. C. Jackson. 2006. University Press of Mississippi, 3825 Ridgewood Road, Jackson, Mississippi USA. 279 pages. U.S.$25. Paper.

Tracks is a collection of 23 short essays, each ranging from 2 to 26 pages. Each essay is built around a personal story of hunting, fishing, trapping or ramblings, and Jackson uses these narratives to provoke thought and contemplation regarding our interactions with and place within nature. While I think his goal is very worthwhile and of great value to anyone interested in understanding our relationship with the environment, I found that he was only sometimes successful. Often the stories are simply entertaining anecdotes, and some essays miss the mark entirely. This is not to detract from the compilation however, as a range of success is to be expected in such a compilation of wide-ranging individual stories. When successful, the author is very insightful and provides much food for thought.

Given this objective however, the musings and philosophies are somewhat confined and repetitive in that all are focused around stories of exploitative nature (hunting, fishing, trapping) whereas some of a non-exploitative nature (camping, hiking, canoeing, drifting, etc.) would be welcome. Such a broader approach would illustrate the connection between a contemplative man and nature in a way that does not require the taking of life. As is, I am left with the vague unease that to "connect" with nature it is necessary to kill something. Dr. Jackson is a professor at Mississippi State University and, given that, I would have appreciated some stories and deep reflections arising from his time in the field on his research. It would show the natural environment giving rise to musings in some other aspect of his life besides the exploitative areas of fishing/hunting/trapping.

Tracks is an interesting book, though I would not recommend it as a must-read. Sometimes the "philosophy" or musings felt forced, but at other times they were very appropriate, flowing from the personal anecdote. The first chapter "Wilderness Before Dawn", really captured my attention and made me hope that I was in for great insight and original perspective. This hope, while not entirely fulfilled, was not entirely defeated either. These essays are clearly intended for a broad audience of readers and in many ways refreshed exquisitely enjoyable past memories for me. I grew up on stories from the magazines *Outdoor Life* and *Field and Stream*, and the stories here are a cross between that type of article and a primer on environmental ethics. As a bridge between outdoor adventure stories and a contemplative approach to nature it is very successful. In addition, while I may not have gleaned profound new insight from the writings, I did learn, and think I have a better appreciation, and respect for, the Deep South of the United States over that when I began the book.

All-in-all *Tracks* is a pleasant read but I would not recommend it as delivering particular insight or a message that we have not heard previously (with the exception of "Wilderness Before Dawn"). For those interested in the rural culture of the Deep South (at least several decades ago), it would be a very useful book. It is the type of book, I think, which is best read in front of a warm fireplace on a cold winter night.

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Why Don't Woodpeckers Get Headaches? And Other Bird Questions You Know You Want To Ask

By Mike O' Connor. 2007. Beacon Press, Fitzhenry & Whiteside Limited, 25 Beacon Street Boston, Massachusetts 02108 USA. 209 pages. U.S.$14.95.

The book *Why Don't Woodpeckers Get Headaches?* is a collection of letters submitted to *The Cape Codder* in the "Ask the Bird folks" column, and answered by Mike O'Connor who is a bird watcher, the owner of a birding store, and a born comedian. The letters ask questions of interest to any backyard birder, ranging from how to attract Bluebirds, to buying the bird bath that's right for you (and your birds) and how to get rid of a squirrel infestation.

The book is divided into eight chapters, each related to a particular area of backyard birding. The first section deals with bringing birds into your yard. O'Connor gives several important tips to attract various birds to your yard, such as having a proper nest box, leaving food that is suited to the birds you hope to attract, having suitable habitat, and most importantly, if you want these birds to stay in your yard, offering birdhouses with low rent, an example of the author's humourous approach.

Other chapters of the book deal with food issues such as: Peanut Butter is it safe? What birds can you attract with oranges? Should you replace your rotten seeds? Another chapter discusses providing some basic comforts for your avian friends: selecting a quality bird house is obviously a key issue, and is talked about extensively. It is safe to conclude from the various entries that, in housing birds, simplicity is key, and while the four story summer villa with the small picket fence and lawn included may look great at the store, your birds would probably prefer the cheaper wooden box. Also, providing a heated birdbath is quite important; contrary to popular belief, birds don't enjoy a chilly swim in the middle of December any more than we do.

Even though this book mostly deals with attracting birds, and encouraging their visits, there is an entire section devoted to bird-related problems. People write in to ask: Why are some woodpeckers more attracted

to metal chimney caps than the peanut feeder? Why do birds insist on chirping in a new day at 4:30 in the morning, right outside their bedroom window? And of course, the timeless question; How to stop their new bird feeder from becoming an all-you-can-eat diner for the cunning gray squirrel? O'Connor provides excellent and thorough advice for his readers, even if he hasn't found a sure-fire solution to the squirrel problem.

Why Don't Woodpeckers Get Headaches is a fascinating collection of people's backyard bird triumphs and tragedies. O'Connor is a talented writer, whose quick wit and edgy humour had this reader crying with laughter. Not only does he answer readers' queries with accurate and detailed opinions, he also provides a brief background look into the bird's appearance and behaviour. The illustrations by Catherine E. Clark are well done and the birds are easily identifiable.

This book is aimed at readers of all ages, and all birding-skill levels, from novice to expert. It is well written and gives a new and often amusing perspective to the world of back yard birding. Even people who are not interested in birds will have a great time reading this book and I would recommend it to anyone. So why don't woodpeckers get headaches? Well, if you want to know, buy the book!

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BOTANY

Alaska Trees and Shrubs. Second Edition

By L. Viereck, and E. L. Little (with contributions by D. F. Murray and E. L. Little, Jr.). 2007. Snowy Owl Books, University of Alaska Press, Fairbanks, Alaska. 265 pages. US$24.95. Paper.

Measured in Cranberries, Alaska must be among the wealthiest states in the world. Although this Alaskan hardcopy publication was printed in China, it was produced with major U.S. governmental support. A long-awaited second edition, its underlying data exist elsewhere in digital geo-referenced format online. For some of the most abundant Alaskan species (willows, over 37 *Salix* species occur in Alaska) the authors present text that simplifies relevant details and identifications.

These complex details are all part of Alaska's wild reality and a management that is mainly oriented on commercial goals. The lack of a GAP project in Alaska (otherwise found throughout all states within the U.S.; see http://gapanalysis.nbii.gov/portal/server.pt) leaves it a large and harmful heritage; e.g., lack of relevant biodiversity management information and digital administrative culture. At least the digital data from this book are available in an older GIS format (ArcGIS 9.0 + Metadata) at the Bonanza Creek LTER website (http://www.lter.uaf.edu) raising hopes of great things to come in the future. This matters a lot, because as the book outlines: "An increasing number of people look to Alaska for wilderness that is no longer present in the more developed areas of the world". It therefore represents a global natural resource leadership issue and role model on how we deal and publish on Alaska's biodiversity and wilderness management components that are so crucial to business and human welfare of the global village.

Together with contributions by D. F. Murray and G. W. Argus, the authors summarize in this book (first edition published in 1972) their life-time achievement presenting up-to-date information on over 14 tree and 115 shrub species. The book offers four identification keys (Key to Alaska Trees and Tall Shrubs Based Mainly on Leaves, Winter Key to Deciduous Trees and Tall Shrubs of Alaska, Key to Genera of Alaska Shrubs, Winter Key to Alaska Shrubs). For each of the 132 species, distribution maps, a descriptive text (usually covering leaves, twigs, bark, wood, flowers, capsules, hybrids, habitat, distribution, uses and notes), paintings and photos (44 color plates overall) are presented. I enjoyed the numerous drawings (mostly taken from Forest Service publications). The plant distribution maps present traditional-style, expert-drawn "polygon monsters" with mathematically exact shapes and margins but are unlikely to represent biological reality or relevant landscape gradients. Some of the general species text information one might find in other botanical key references. However, readers interested in Alaskania will appreciate the many species details provided. For instance "Alaska Athabascans eat the fruits raw or cooked in moose fat" (for Silverberry), or "Alaska Indians used the wood for totem poles, dugout canoes, and houses, and made mats, baskets, and ropes from the stringy bark" (for Western Red Cedar).

The reader of this book will appreciate the incredible diversity (and abundance) of willows, birches, and berries (e.g., Blueberry, Bearberry, Cranberry, Huckleberry, Snowberry) in Alaska. But environmental problems, widely cited in geo-botanical publications, such as climate change, endemic species loss, road impacts, overcutting, nitrogen input and general human footprint found throughout Alaska are sparsely treated). Oil development, or pipeline impacts, key features in Alaska's landscape and recent history, and discussed almost worldwide with high-profile books devoted to this issue (see for instance National Research Council of the National Academies 2003), are hardly even mentioned.

The authors maintain a dubious and ecologically non-sensitive view that "...the distribution of trees and shrubs have changed little" since the 1970s. However,

at least the changes for Greene Mountain Ash and Creeping Juniper are described. The concepts of (Landscape) Ecology, Biogeography, Fragmentation, Biodiversity, and related loss of plant DNA are virtually omitted in this book. With great regret one has to see once more that the impact of the Intensive Management Law (signed 1994 by Governor Hickel; maximizing moose numbers through non-science based predator control, and thus severely affecting browsing on shrubs and vegetation Alaska-wide) remains virtually unmentioned. But the impact of ANILCA (Alaska National Interests Land Conservation Act) in 1980, and the number one problem of the Alaskan National Parks, invasive species, is mentioned (over 100 invasive species are referred to, but only 9 are described in this book; for a better description the reader is advised to visit websites such as http://www.ucsusa.org/invasive_species/state-invasion-portfolios.html and http://www.uaf.edu/ces/ipm/plants/index.html). Many of these species were introduced with governmental help, even by agencies that now have to spend huge amounts of their budget to deal with these earlier sins. The book section on Transplanted Native Species I found very informative (e.g., for Sitka Spruce: "During World War II, the U.S. military had an active program of planting trees near bases in the Aleutian Islands."). Other environmental topics mentioned are facts like "Much Alaska cedar is exported to Japan in log form...", or for Sitka Spruce: "Low-grade lumber is made into packing boxes for the Alaska salmon industry". Keep in mind that the Tongass and Chugach Forest is the largest temperate rainforest in the world, with an extensive network of forest roads reaching more than 10 times around the world! Fortunately, the authors leave no doubt that more forest exploitation will occur in Alaska. Such an outlook makes one shiver for Alaska's future well-being; plants included.

But Cranberry juice apart, "Alaska is a land of contrasts in climate, physical geography, and vegetation" providing a great country for botanists with a thirst to explore. Besides many endemics, it harbours the Quaking (Trembling) Aspen (most widely distributed tree in North America) as well as the largest cottonwood known until 1965. And so, the book is full of fascinating Alaskan landscape details such as nunataks, ice fields, permafrost, and some fire history. The prominent botanist Robert Marshall and his historic seedling experiments are also mentioned. But relevant Russian, Chukotkan, Kamchatkan and Bering Sea botany are not further dealt with, nor the links to the Yukon, British Columbia or the circumpolar Arctic.

It appears a botanical religion that a vegetation classification always has to be carried out in such botanical books and landscapes. Therefore, this publication offers 8 main vegetation types and their leading species for Alaska (published by the U.S. Forest Service 1971; but relevant quantitative analysis details are not provided, and one has to trust the experts blindly once more).

The underlying botanical species taxonomy of this book is still in flux, as can be seen in the large number of hybrids, or in the alder, birch and willow species complexes. Such dynamic and complex taxa are not easy to deal with by using classic governmental hardcopy black-and-white publication philosophies (the authors followed for instance the *Flora of North America*, Furlow 1997 and Argus 2004). It is here where readers need more leadership from the experts. Perhaps presenting links with Genbank (http://www.ncbi.nlm.nih.gov/Genbank/GenbankOverview.html) and ITIS (http://www.itis.gov/) would start this concept?

The general audience will appreciate the two Alaskan botanical maps and the four page glossary of botanical terms. A seven page index of Common and Scientific Names, and the six pages of literature are of further interest.

The authors state the contributions from several agencies and funding institutions, including the U.S. Forest Service and the Museum of the North Herbarium Database. Unfortunately, botany is often equated with timber, and, as elsewhere, a governmental forest service focus and its cultural bias can be found in this book. For instance, from an Arctic tundra perspective, I am disappointed not to find any relevant references from S. Walker in this book; the reader is advised to see online for CAVM http://www.geobotany.uaf.edu/cavm. But despite the forestry involvement, the authors still make a nice case that "...the forests of Alaska provide more than timber to the people of Alaska, and the rest of the United States". Well spoken.

This book well describes what Alaska currently has to offer: wide terrain, many new botanical findings that are waiting to be put in order (à la: "we sort 'em postmortem"), and much relevant ecology and sustainable management waiting to be done. Curious naturalists might also want to compare the state of the art in Alaska with the *Flora of adjacent British Columbia* (http://www.eflora.bc.ca). One assumes that the future will likely see digital online species pages, such as already started in Wikipedia and coming forward in GAP and GBIF, with a Biology Google ("Boogle", or Poogle for Plants) just being around the corner. This books makes for a great step towards this achievement for Alaska, its cranberries and beyond.

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ENVIRONMENT

The Atlas of Climate Change: Mapping the World's Greatest Challenge

By Kirstin Dow and Thomas E. Downing. 2006. University of California Press, Berkeley, California, USA. 112 pages. US$23.95 Paper.

An atlas suggests maps, and maps there are in abundance in this volume, though it also contains many graphs, charts, diagrams, and informative explanatory text. Although short, this book is packed with useful information and well repays careful study. The atlas is divided into seven sections, each focusing on a different aspect of the climate change story and each preceded by a one-page introduction. For the first five sections, topics are illustrated primarily by mapped data, usually at a global scale, though occasionally focusing on a specific region, such as the Antarctic. The maps are usually supplemented by a few paragraphs providing some additional background or explanation for the displayed data. The atlas is sprinkled with quotes, though these are mostly undated, which rather diminishes their urgency or relevance to the issues.

Part 1, Signs of Change, highlights some warning signs, such as the European heat wave of 2003, and then covers three aspects of climate change that set the context for the rest of the book. These three aspects comprise glacier retreat, weather-related disasters, and changes in the polar regions, areas that have been identified as having particular sensitivity to climate change. These topics are likely to be familiar to Canadian readers through various recent media stories. Part 2, Forcing Change, focuses more directly on the climate system, covering four topics, mostly through charts and diagrams. Two aspects of the climate system are highlighted, explanations for the greenhouse effect and how climate operates in terms of heat transfer across the globe. This section also provides a long-term perspective on climate change, showing the record of carbon dioxide fluctuations for the last 400 000 years derived from ice-core records. Finally, there are some scenarios, based on various model projections, showing projected carbon dioxide increases and related temperature increases.

The following three sections form the bulk of the atlas. With six topics, Part 3, Driving Climate Change, examines greenhouse gas production in more detail, highlighting several critical aspects of modern industrial activity and linkages to fossil fuels, especially transportation and agriculture. Covering seven topics, Part 4, Expected Consequences, paints a grim picture, showing, amongst other consequences, the impacts of rising sea levels, water shortages, and threats to human health. Africa stands out as the region likely to be most severely affected in the last category. One of the most interesting maps in this section deals with cultural losses, including historical and archaeological sites. These kinds of impacts are not often highlighted in discussions of climate change. On the other hand, biodiversity losses and biogeographic changes are given very little attention. Since alterations in plant and animal distributions are some of the more obvious and visible signs of climate change, I found this rather surprising. For Canadian readers, these sections may induce both complacency and embarrassment. Complacency because the maps show that on an absolute basis, Canada does not contribute as much to the problems as other more populous industrialized countries. Embarrassment because on a per capita basis we consume so much compared to so many countries of the Third World. Such reflections form a natural transition to the last sections of the book.

Having provided a gloomy outlook in the previous section, Part 5, Responding to Change, shows what we can do about it, or how we might be able to modify the outcomes at a macro-scale. Eight topics are presented, most of which are focused on institutional or administrative responses, such as carbon trading or development of alternate renewable energy sources. Finally, Part 6, Committing to Solutions, shifts the focus from the global to the local, with some charts showing how individual actions might affect the trajectory of change. For those who want the "nitty-gritty" details, Part 7, Climate Change Data, tabulates various measures of economic activity and consumption on a country-by-country basis. These data underpin the maps and graphics in the rest of the book.

Generally the book concentrates on the more obvious impacts of climate change and the ones that are often the focus of media attention, such as potential limits on water and food supplies. As such, most readers are likely to have at least some passing familiarity with the issues. This book therefore serves as a useful source or companion book for those seeking more background on current issues. More subtle effects of climate change, such as water quality degradation, or cascading effects, such as wildfire frequency changes or aquifer depletion, are not shown, perhaps because these are less amenable to measurement or estimation and mapping. Moreover, the emphasis throughout is on impacts to the terrestrial realm; other than sea-level changes, very little attention is paid to marine systems. Again, this is perhaps surprising given the linkages that have been found between, for example, the ENSO (El Niño-Southern Oscillation) with rainfall and droughts.

Cartographically, the book is attractive, clear, and well-designed. It is apparent that a great deal of thought and care has been paid to the layout, presentation, and overall design. In my view, the design is one of the book's greatest strengths. Many people are "visual learners" and this book will definitely appeal to anyone that prefers graphics to text. Most of the global presen-

tations use the same map projection, with Europe and Africa in the centre and the Americas and Australasia at the extreme left and right. For North American readers, this projection can seem strange, since we are more used to seeing the Americas displayed centrally with other continents on the periphery. Much of the base information is quite complicated but the maps show good use of colour and symbols to convey information and summarize complex ideas. One of the more interesting maps shows greenhouse gas emissions, with countries' size distorted according the amounts emitted. The effect is quite startling, with the dominance of the industrialized regions (USA, Europe, CIS, and East Asia) standing out. Perhaps more telling is the minuscule contribution from Africa, which shows up as a small polygon, despite its large land area and population.

Even with the references and sources, I did find myself wondering exactly how some of the figures underlying these maps are derived, especially because so many of the data are presented at a regional level, where regions may include several countries, and are "binned" into a few categories to simplify cartographic presentation. Uncertainties or error estimates are not provided for the data. Inevitably, there must be some fairly broad assumptions and generalizations underlying the figures. To take one example, what kinds of measurements could be available to allow an estimate of methane emissions on a per capita basis? Are the same or comparable measurements, that is, the same data quality, really available for all areas of the world? How are data integrated even within one country, given that there are different ecoregions and uneven population distribution? How much of the disparity shown is real and how much attributable to varying levels of data available for different areas of the world? In fact, how far are the numbers behind the maps realistic estimates based on reliable instrumentation or simply informed "guesstimates"? Notwithstanding the beguiling presentation, I did find myself asking many questions about the methodology behind the mapping.

Perhaps the greatest drawback with this book is that, because it deals with current and rapidly changing issues, the information presented will quickly become dated. The authors note that no new material was added after spring 2006, but they also indicate that they intend to update the volume, especially after the next Intergovernmental Panel on Climate Change (IPCC) report, expected in 2007 (page 13). It will be interesting to see how future editions compare to this one and whether detectable changes in some of the indicators show up on that time scale. One could argue that such information is better presented on a website, where it could be updated as needed. However, having the information gathered together in book form makes it easier to consult and compare the different maps. The book's greatest advantage is its accessibility, with its clear presentation and distillation of an enormous amount of complex information into a readily understandable format.

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An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It

By Al Gore. 2006. Rodale, New York, USA. 328 pages. US$28.95 Paper.

I freely admit that I picked up this book already predisposed to dislike it. After all, it's supposedly a book about climate science by a politician, so how good could that possibly be? I am relieved to report that this volume pleasantly surprised me; the book is considerably more readable and worthwhile than I expected it to be. Surprisingly, it also projects, an air of intelligence and careful consideration. Yes, the book is a call to action and a strong statement of a particular point of view, but the hype and hyperbole are at a lower volume than I had feared. More importantly, the book is largely based on solid science and the presentation of that science is done in a remarkably straightforward fashion.

In his introduction, Gore says that the book was developed from a slide show and, judging by the layout and design, that presentation mode has carried over and set the book's style. It is arranged as a continuous narrative, with clear graphs and graphics, some on fold-out pages, colourful eye-catching photographs, short sentences and paragraphs, and large type. Graphics are sourced, though complete citations are not provided. Text and explanatory captions are generally written in plain conversational language. The book surveys the evidence for global warming and outlines the main forcing factors, highlighting the importance of greenhouse gases and the role of human activities in the increasing rate of, especially, carbon dioxide content in the atmosphere.

Gore drives home the message that human activities, in particular industrial activities, are responsible for much of the recent increase in greenhouse gas concentrations in the atmosphere and therefore the increasing rate of global warming. He sets these trends in context by showing, for example, recent rates compared to the carbon dioxide trend inferred from Antarctic records extending back to 600 000 years before present. Other long-term records, such as tree-rings and Greenland ice-cores, are also used to provide perspective. Several times, the point is made that it is not simply the absolute amount of increase that is important but the increasing rate of increase. Taking it as given that global warming will continue, even if actions are taken now to reduce rates of carbon dioxide emissions, Gore then exam-

ines what the implications are likely to be during the next few decades.

The book presents many different types of evidence for global warming and covers a lot of territory. It draws on data and images from across the world. Gore amasses a formidable array of information to support his argument. Some of the topics he features include: droughts and shrinking lakes (including an intriguing sequence of images showing the reduction in Lake Chad), reduction in Arctic ice, shrinking of large ice sheets (notably on Greenland and Antarctica), effects on temperatures and seasonality, impact of rising sea-levels (including the inundation of islands), damage to coral reefs, effects of climate on human health and diseases rates, frequency and occurrence of extreme weather events (including, not surprisingly, hurricanes), and climate impacts on biodiversity and distribution of plants and animals. The evidence for global warming includes some striking "then and now" photographs of glacier forefields showing recent ice retreat. Two issues that also stand out are the effects of exceptionally high summer temperatures, as seen in recent years in Europe especially, and increased storminess, especially on low-lying islands and coastal areas. The evidence and implications are shown from a global and not just a U.S. perspective. This worldwide coverage underlines the urgency of the issues presented, since some of the impacts are not just hypothetical but are being felt by people across the world now.

This leads Gore into a consideration of the roots of the problem, in particular the main sources of greenhouse gas emissions. Some striking graphics visually emphasize the large contribution to greenhouse gas emissions made by the U.S. Gore points out some of the global inequities in consumption that have led to this situation and militate against any remedial action. He identifies energy production as the main culprit and highlights the need to move to alternate energy sources, such as wind power. Here, the text gets more overtly political with Gore taking aim at the Bush administration for obfuscating the issue and refusing to act, for example, by not ratifying the Kyoto Protocol.

Interspersed within the text are eight short essays, most of which recount anecdotes and incidents from Gore's life. These stand out from the rest of the narrative by being printed in smaller font on tan-coloured pages. The essays highlight some of the reasons for his passionate concern about global warming. What they show is that this is not a recent preoccupation but something that has engaged his attention for many years, growing out of life-long interest in environmental issues. Clearly, he wants to let readers know that he is not simply "jumping on a bandwagon" and taking up a trendy issue out of opportunism, but is following an interest that has underpinned his political career. Here, I did feel that I was reading a political manifesto at times. There's a lot of name-dropping and there are rather too many "warm and fuzzy" pictures of Gore and his family for my taste. Nevertheless, these essays bring the issue from the abstract to the personal, which does sharpen the sense that these concerns matter to individuals. By being set off from the rest of the text, it is clear that the message in these essays differs from the rest of the book.

The final section of the book, offset by being printed on light-green paper, is the call to action, outlining some things that individuals can do to make a difference. Most of these actions will already be familiar to most readers: buy a hybrid car, bag your groceries in re-usable shopping bags, replace incandescent light-bulbs with compact fluorescent bulbs, and so on. Generally, these actions are an appeal to a sense of guilt in affluent people living in western countries, where, Gore maintains, most of the problem originates anyway. Some of the suggestions run counter to many driving forces in the economy. When the TV screen is filled with ads encouraging us to be tourists and travel to sunny beachside resorts, how realistic is it to tell people to reduce air-travel? Interspersed among these exhortations are ten common misconceptions about global warming and Gore's recommended responses. These misconceptions include the ones you might expect, such as the assertion that "it's all just natural variation", though there was one I hadn't heard before, attributing global warming to after-effects of the Tunguska event.

In such a brief statement of the global warming issue, Gore obviously does not get into any topic in detail. There's clearly a lot more that could be said about all lines of evidence he presents but, unfortunately, there is no reading list for readers to follow up on any topics raised in the book. Nevertheless, Gore does assemble a persuasive argument that global warming is a problem and we need to do something about it immediately. However, this is very much a book that is "preaching to the converted". I can't see many people who are not already convinced there is a problem reading it. On the other hand, Gore is a well-known figure so perhaps some people may take a look at this book because of name-recognition. As a politician, Gore has to overcome a good deal of cynicism in order to reach people. This is a pity because this book is an articulate and thought-provoking presentation of a global phenomenon that affects us all.

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MISCELLANEOUS

Gilbert White: A Biography of the Author of *The Natural History of Selborne*

By Richard Mabey. University of Virginia Press, Charlottesville. 2006. 239 pages. U.S.$16.50 Paper.

In his introduction, Mabey admits that, at his first reading of Gilbert White's *The Natural History and Antiquities of Selborne,* he could barely cope "with its rambling disorder." Only on visiting Selborne in person did Mabey change his view decisively. I marvel, as Mabey did, that White "could produce something so wholly original and appealing out of such unpromising ingredients."

In this Whitbread Prize-winning biography, the painstaking research of Mabey – whom the *Times* has called 'Britain's foremost nature writer' – results in a remarkably detailed account of the life of Gilbert White. Born in the tiny village of Selborne, White obtained his university education in theology at Oriel College, Oxford, beginning in 1739. Here he met John Mulso, in the year behind him. Although "constitutionally lazy and hypochondriacal," Mulso's life-long correspondence to and from White became a major source for Mabey. Perhaps it was equally providential that White was not particularly successful in his first three appointments to curacies at a distance from his home. When he returned to Selborne he began, somewhat inauspiciously, to commit his nature observations to paper in 1756.

White was patient and inquisitive. His early description in 1761 of the life of crickets was both "vivid and sensuous." In 1767 he began writing to the naturalist and author, Thomas Pennant; two years later he began his original observations that helped prove that birds migrate. In 1774, White's lively letters to Sir Daines Barrington included one about house martins, which Barrington read to a meeting of the Royal Society. The result was publication of these "models of lucidity and insight" in Britain's earliest scientific journal, *Philosophical Transactions.*

Finally, late in 1788, at age 68, White had the satisfaction of seeing his book in print. He died in June 1793, a month short of his 73rd birthday, modestly unaware of the prominence his book would achieve in the centuries to come. Second and third editions did not appear until 1802 and 1813, respectively, but there have been more than two hundred subsequent editions, one of the most published books in the English language.

I appreciated Mabey's delightful biography all the more because I, too, have visited Selborne. By learning more about Gilbert White, we can better appreciate White's impact on all subsequent nature writing. I congratulate the University of Virginia Press for making this inexpensive reprint, first published in hard cover in 1986, readily available to North Americans. I heartily recommend it to anyone with the slightest interest in English literature or the history of natural history.

C. STUART HOUSTON

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A Paddler's Guide to Quetico and Beyond

By Kevin Callan. 2007. The Boston Mills Press, Erin, Ontario Canada. 192 pages. U.S.$24.95 Paper.

It's the dead of winter on a Friday evening when friends lay out the maps on the floor in front of a burning fire. Over wine, possible routes are discussed and commitments are made for a canoe trip six months hence into one of the most intact, accessible and largest protected wilderness areas in North America: Quetico Provincial Park. This is a book that will lead you beyond your usual canoe routes; in fact, it may inspire you to plan a trip celebrating Quetico's 100th anniversary in 2009!

Kevin Callan is no stranger to writing books on wilderness canoeing with seven "Paddler's Guides" for Ontario canoe routes to his name. Kevin reminds us that there is a great story to be told after every canoe trip we make, as a result of spending quality time with a group of family or friends on a journey through the natural world of wind, water, wildlife and plants, complete with portages, bannock and fireside stories. Each of the sixteen canoe routes described in this book is a well-written informative story, weaving important practical information such as the take-out and put-in spots for portages, special sites to see, and danger spots – into historical accounts of those who were here long before our forays using Kevlar canoes and Gortex. The stories also convey the hardships and joys shared by the group traveling with Kevin; the "real stuff" that makes canoe trips memorable.

The book does not overwhelm the reader with unnecessary detail on the gear to bring, what kind of canoe paddle is better than another, etc., rightly assuming someone heading to Quetico is not a novice. At the same time, simple, straightforward descriptions of canoe routes make them immensely doable for the average paddler. Exceptional pictures and tidy maps are also included, with references for the "proper" maps a canoeist must purchase in order to undertake these trips

Sixteen canoe routes are described in *Quetico and Beyond*; eleven in Quetico Park and five within neighboring areas of northern Ontario. Most routes require about one week to complete, although some are as short as 2-4 days and others as long as 28 days. Summaries provided for each of the canoe routes includes

number of days required to complete the route, the number of portages, the longest portage, route difficulty, access points, and the maps needed. Scanning the summaries provides a quick method to narrow down which routes look the most interesting within the time frame and abilities of the group.

Quetico is a book that provides very readable pleasant conversation that, in a personal way, brings canoeing to life through its past and more recent adventures. The many reminders of the subtle rewards of canoeing that are conveyed provide a real enticement to begin planning your next trip.

BRENT TEGLER

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More than Kin and Less than Kind: The Evolution of Family Conflict

By Douglas W. Mock. 2004. Belknap Press of Harvard University Press, Cambridge, Massachusetts, USA. 267 pages. U.S.$27.95.

If you wish to understand how complicated and how variable reproductive behaviours can be, this is the book! Doug Mock offers a wide vista of nature in all its infinite variability and complexity. To explain bird behaviour, Mock invokes human examples, as diverse as his three older brothers, chess, Wall Street, sports teams, and vote counting.

Mock offers creative chapter headings and begins each chapter with a brilliant quotation. He simplifies difficult-to-understand concepts in an instructive and often entertaining manner. As he says, this book is a "mixture of theory and data." He is especially interested in brood size and in siblicide. I will offer a few highlights, some of which mention Canadian research.

Mock attempts to explain both the "hows" and "whys" of concepts that include Darwinian fitness, evolutionary game theory, inclusive fitness theory, evolutionarily stable strategy, parent-offspring conflict, parental manipulation, optimal clutch size, replacement offspring, and the insurance egg hypothesis.

Reproduction is costly. When Collared Flycatcher broods were enlarged artificially, there were fewer breeding adults the following season, and when two eggs were removed, females laid larger clutches the following year. Seychelles Warblers produced 77% male chicks in poor habitat and 88% female chicks in good habitat.

Lifetime monogamy is uncommon among birds but there are notable exceptions. A sample of 919 pairs of Bewick's Swans showed not a single divorce, but if a mate died the survivor would re-pair. From a sample of over 6 000 banded birds, 99.6% of Barnacle Goose pairs were socially monogamous.

Mock discusses Hamilton's rule, promulgated in 1964, whereby "two full siblings should be the evolutionary equivalent of one Self" – or eight cousins – based on the amount of shared genetic material. Altruistic behaviour, such as nest helpers, relates to the mix of relatedness.

What happens in nature often seems counter-intuitive if not outright bizarre. Biologists have difficulty understanding, much less explaining, such events. What conceivable evolutionary advantage could result from a surplus egg or surplus young? Why do some species of eagle and pelican regularly lay two eggs, yet raise only one young? Why does a parent bird passively watch one of its nestlings kill another, even when surplus food is within reach? Why does a hawk nestling sometimes eat its sibling after killing it, but on other occasions does not?

At Delta Marsh, Manitoba, Spencer Sealy videotaped nests with a single cowbird and a single warbler; the cowbird out-hustled, out-begged and out-stretched its warbler nestmate. In British Columbia, Bruce Lyon studied American Coots, which lose some chicks to starvation in nearly half the broods. Adult coots make a point of getting more food to the youngest, but when Lyon clipped the bright ornamental plumage of the tiny chicks, the clipped birds survived less often.

The late Roger Evans of the University of Manitoba did experiments to study the role of the extra or "insurance" egg in the American White Pelican. He and his student Kevin Cash carefully marked the first-hatching or A egg, and the second-hatching or B egg. Twenty percent of the B eggs hatched. The parent pelican would brood its young, but as soon as the parent stood up, the older young attacked its smaller sibling.

Wahlberg's Eagle, which ranges across central Africa, lays a single egg; not more than three percent of pairs lay a second egg and then the larger chick regularly kills the smaller one.

The Verraux's (Black) Eagle lays two eggs, but an observed first chick began assaulting the second chick soon after it hatched, giving 1 569 blows with its beak to kill its sibling, even though food was plentiful in the nest. The Crested Penguin lays two eggs, but the first egg is up to 40 percent smaller; four days later the second, larger egg is laid and is given the optimal brood patch position beneath the mother, and is usually the sole survivor.

Mock does not restrict himself to birds. He writes about plants, insects and fish, using the firefly as an example of signalling. He tells how, in a pig litter, anterior teats produce more milk than posterior teats, hence the colloquialism, "sucking hind teat."

As Marlene Zuk says on the dust cover, this book about family conflict "is a model of how behavioral ecology can and should be done … Just don't take it to family reunions."

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To See Every Bird on Earth

By Dan Koeppel. 2005. Hudson Street Press, New York, New York, USA. 278 pages. $24.95 U.S.$35.

Dan Koeppel tells the story of his father, Dr. Richard Koeppel, a chronically unhappy medical doctor with two overwhelming obsessions: to see as many species of birds as possible, world-wide, and to read, cover to cover, every novel that was short-listed for or won the Booker Literary Prize.

Each chapter begins engagingly with a postage stamp that features a bird from the collection of Chris Gibbins who has amassed stamps depicting 2950 species (a record list!), and a paragraph from Richard Koeppel's notebooks telling of a numbered addition to his life-list.

One learns about the methodology of listers, particularly the rules laid down by the American Birding Association (pages 195-197). Dan explains, in layperson's terms, "lumping" and "splitting" of species. Despite the ever-escalating CPB (cost per bird), Dan fully realizes that the listing process is "intensely arcane, fascinating, and absurd."

This is a quick and easy read, but in no way uplifting. Dan's brutally frank, very personal psychoanalysis of his father and mother is somewhat excessive and distracting. Dr. Richard Koeppel, it seems, entered medicine to please his parents, and sadly failed to find a fulfilling niche in medicine. His marriage failed early. He became a morose, rather pathetic man who found solace in excessive use of marijuana, alcohol and nicotine. Most of his career was in emergency medicine, where roughly half his time could be spent birding. When his bad habits caught up with him in the form of larynx cancer, Richard Koeppel's personal list was at 7080 species.

I most enjoyed the behind-the-scenes accounts of Jim Clements, who compiled the first one-volume list of birds of the world, and has amassed a personal life list of 7200; Victor Emmanuel, who began the first field trips designed to add maximum numbers of birds to each customer's life-list; and Bret Whitney, who lacks formal postgraduate education in ornithology but has succeeded the late Ted Parker as a finder and describer of new species in South America.

One also meets Richard's competitors. Within our region, North and Central America, Dan Canterbury has seen a record 1731 species. Peter Kaestner, who traveled widely in the diplomatic service, was the first person to have seen a representative of all 159 avian families. Others in competition with Richard Koeppel for the world list have been Harvey Gilston of Britain, who, without ability to identify the bird himself, would check off a bird when a guide called out its name (he reached nearly 8000); Michael Lambarth and Sandra Fisher of England (Michael quit when his beloved partner died); Joel Abramson, a medical doctor who hired top birders to lead endurance-test expeditions; Stuart Keith, founder of the American Birding Association, who was recognized by the Guinness Book of World Records when his list reached 4300; Roger Tory Peterson, who reached the "half-way total" of 4800 in the 1980s; Bill Rapp, nearing 7000; Jim Plyler, a retired oil executive at 7200; Peter Winter and John Danzenbacker, military men, at 7800 and about 7750, respectively; Peter Kaestner, with 7958; Tom Gullick, leader of those still alive, with 8114; Phoebe Snetsinger, still tops, who reached nearly 8500 before she died in a car accident in Madagascar in 1999.

What are the downsides to this book? The title is a bit misleading, since Dan Koeppel knows full well that no human will ever see every bird (of about 9600 species) on earth. An index to birder's names would have been helpful. Worse, Richard Koeppel, the protagonist of this story, is a sad and pathetic person, lacking enthusiasm for his profession, with complicated marital and family situations. He is a perfectionist but only on rare occasions does he show much feeling, even for birds. But Richard has made amends with his son, Dan, and has recently turned his attention to butterflies.

All readers of this review, especially the writer, are sinners. We claim to be environmentalists, yet many or perhaps most of us drive gas-guzzling vehicles to pursue our sometimes obsessive hobby. At least we fall short of the obscenely high travel expenses of certain of the Big Listers.

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Wildfire in the Wilderness

By Chris Czajkowski. 2006. Harbour Publishing, Madeira Park, British Columbia, Canada. 221 pages. $19.95 Paper.

A woman who lives a solitary life in the wilderness of the British Columbian mountains, dozens of kilometres from her nearest neighbours, has not isolated herself from her community. Her life is a heart-warming set of tales explaining the connection she has to the community of mountain dwellers, outfitters, and bush pilots in her immediate neighbourhood as well as friends, publishers, fans of her books and international tourists in the wider community. The reader is introduced to her dogs, her history of publications, her ingenuity in building and maintaining a wilderness site and even the state of her bank account while following her stories of maintaining solitude in the mountains and contacts with the outside world.

A hiker, camper and outdoorsman would certainly relate to Chris Czajkowski's stories and her descriptions

which make the mountains a home. The well-being of the environment becomes close to the heart of any dweller of the wilderness and the threat of nature taking a turn for the worst can send dwellers of the backwoods to worry over their personal charge, the nature and landscape around them. Sustained inclement weather, freak storms, too much snow in a season, frost at the wrong time, drought in the wrong season or prolonged drought in any season, are all causes for worry but a natural disaster like a wildfire is feared above all. Though the title tells us only of one dramatic event in the history of her lake, cabins and near environment, the reader is drawn into her whole lifestyle of protecting, nurturing and living within the environment which she has come to call home.

As the story unfolds, Czajkowski leads us into her world, travelling long distances, keeping up with modern technology, camping and hiking with her tourist helpers. She is home in her particular isolated part of the world a long way from her nearest neighbours but connected with them by regular radio conversations, listening to radio broadcasts and occasionally eavesdropping on her neighbours' conversations, and finally email as that technology became available. At the same time, she is host to the world by operating a small guest house for people willing to travel the distance to spend a few days with her, or international wanderers who pay by passing a few weeks working and helping her with projects.

Finally the reader is led to the hot dry summer of 2004 and the devastating fire, the Lonesome Lake Fire which was well reported to the Canadian public as one of many fires in a hot dry summer, but to people of that remote region, a disaster which shaped their environment for years to come. The reader is invited to travel with Czajkowski through the fear and uncertainty of watching gathering smoke and distressing news from various watchers in neighbouring valleys. We are inspired to evacuate with her to safer areas, but without any assurance that home or lifestyle could be preserved. Czajkowski leads us along her tale with interesting anecdotes and humorous stories about her dogs, friends, and people who come to visit her. She is an engaging story-teller and keeps the reader's attention for hours or just a few minutes at a time as the book is filled with short stories, portions of her diary and longer accounts of specific incidents.

The story builds in an entertaining way through her history of building the cabins, receiving visitors, including facts about making one's life in the wilderness at the same time maintaining connections firmly planted in the outside world. The fire is the high point of the book and gets the reader to the excitement of living her experience of the fear, doubt, loneliness and response of care for her own animals and the natural dwellers of her wilderness world. The reader enters into the story with her and can live the excitement she feels. In our sheltered world, our decisions are not always the same as the author's but she puts her concern and care for her environment in front of the reader and shows us a different world to enjoy for a little while then look forward, like her globe-trotting visitors, to the next visit we might have with her.

JIM O'NEILL

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YOUNG NATURALISTS

Tale of a Great White Fish

By Maggie de Vries. Greystone Books, Douglas & McIntyre Publishing Group, Vancouver, British Columbia, Canada. 34 pages. $12.95.

The book *Tale of a Great White Fish* follows the story of a giant white sturgeon. Through its long life, the sturgeon overcomes many obstacles in its battle to survive and reproduce. The story deals with the interaction between sturgeons and people, along the way providing the reader with a wealth of information and insight into the natural history of the sturgeon.

The story starts in 1828, when the sturgeon, named "Big Fish," was a small and defenceless egg hatched in the Fraser River. She matures into a larva and then into a fry. As a fry she must eat thousands of other small water creatures to grow. Fry are also especially vulnerable to predators, and most of the young fry never reach adulthood. The fry that survive mature into adults before returning to their spawning ground to lay their own eggs.

There are many dangers that the sturgeon must overcome. For most of their long existence sturgeon have been around since the time of the dinosaurs, the threats have been natural: predators, natural calamities and disease. Today, human fishermen and the caviar industry are one of the greatest perils. Big Fish was hooked by a fisherman, but fortunately she was freed by some young boys and was able to escape. During the Hells Gate Slide in 1913 many migrating sturgeon were killed. Big Fish survived, but she was forced to find a new place to spawn. Later, Big Fish had to find a new home because the lake she was living in was drained. Later still, an unknown disease swept through the Fraser River and many sturgeon died and were washed up on the shores of the lake. When the story closes, almost a hundred years later, Big Fish is still surviving, but continues to face many challenges.

Scientists study sturgeons to help them survive. They keep track of their weight and size, and try to stop overfishing. There are now laws which prevent the fishing of these magnificent animals.

The book is written as a story and at the end there is a useful list of sturgeon facts, a labelled diagram of a

White Sturgeon, a glossary, and a letter from Rick Hansen, a famous Canadian para-athlete. Rick Hansen is the chairman of the Fraser River Sturgeon Conservation Society. The drawings by Renné Benoit are done in water colours and they provide a magnificent glimpse into the beautiful and dangerous world of the great White Sturgeon.

The book is very informative. In it, the reader will learn a great deal about the White Sturgeon's environment and behavior and appearance. The Sturgeon Facts and a glossary at the book of the book provide a very useful summary, and is well presented.

The book is aimed at a child's reading level. Older readers would find this book less interesting; however, it provides a basic insight into the world of a great white fish and is nicely illustrated. This book is recommended for any child with an interest in the outdoors and in nature.

JESSICA GAWN

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NEW TITLES

Prepared by Roy John

†Available for review * Assigned

ZOOLOGY

Bird – The Definitive Visual Guide. Edited by Peter Frances et al. 2007. Dorling Kindersley, DK Enquiries, Tourmaline Editions Inc., 662 King Street West, Suite 304, Toronto, Ontario, M5V 1M7. 512 pages. GBP 25.99 Cloth.

The Black Bear Almanac. By David Smith. 2007. Globe Pequot Press, 246 Goose Lane, P.O. Box 480, Guilford, Connecticut 06437 USA. 288 pages. U.S.$29.95.

*** The Clements Checklist of Birds of the World (6th edition).** By James F. Clements. 2007. Cornell University Press, Sage House, 512 East State Street, Ithaca, New York 14850 USA. 864 pages. U.S.$59.95 Cloth.

The Biology of African Savannahs. By Bryan Shorrocks. 2007. Oxford University Press, New York, New York. 268 pages. GBP 27.50 Paper.

Arctic Flight – Adventures Amongst Northern Birds. 2007. James McCallum. Langford Press, 10 New Road, Langtoft Peterborough, UK. 180 pages. GBP 37.99 Cloth.

Endangered. By George C. McGavin. 2007. Cassell Illustrated, 2-4 Heron Quays, London E14 4JP. 192 pages. U.S.$35.

*** Birds of Europe, Russia, China, and Japan: Passerines: Tyrant Flycatchers to Buntings.** By Norman Arlott. 2007. Princeton University Press, 41 William Street, Princeton, New Jersey 08540 USA. 240 pages. U.S.$29.95 Paper.

Feathers: Identification for Bird Conservation. By Marian Cieślak and Bolesław Dul. 2007. Natura Publishing House, ul. Olbrachta 118c/20, 01-373 Warszawa, Poland. 320 pages. GBP 25.62.

Forensic Entomology: An Introduction. By Dorothy Gennard. 2007. John Wiley & Sons Canada Ltd., 6045 Freemont Boulevard, Mississauga, Ontario L5R 4J3 Canada. 244 pages. U.S.$55 Cloth.

Homalopsid Snakes, Evolution in the Mud. By J. Murphy. 2007. Krieger Publishing, P.O. Box 9542, Melbourne, Florida 32902-9542 USA. 260 pages. U.S.$68.50 Cloth.

The Inner Bird – Anatomy and Evolution. By G. Kaiser. 2007. The University of Washington Press, P.O. Box 50096, Seattle, Washington 98145-5096 USA. 464 pages. U.S.$85 Cloth.

Insects of Britain and Western Europe. By Michael Chinery. 2007. A & C Black Publishers Ltd. (United Kingdom), 37 Soho Square, London, W1D 3QZ. 320 pages. GBP 14.99 Paper.

Insect Conservation Biology. Edited by A. J. A. Stewart, T. R. New and O. T. Lewis. 2007. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 480 pages. U.S.$190 Cloth.

Australia's Mammal Extinctions. By Chris Johnson. 2007. Cambridge University Press, 40 West 20th Street, New York, New York 10011-4221 USA. 278 pages. GBP 34.99 Paper.

Owls of the United States and Canada. By W. Lynch. The University of Washington Press, P.O. Box 50096, Seattle, Washington 98145-5096 USA. 256 pages. U.S.$44.95 Cloth.

Spotted Owls. By J. Hobbs. 2007. Greystone Books, Suite 201, Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 144 pages. $39.95 Cloth.

Birds of Pakistan. By Richard Grimmett and Tim Inskipp. 2007. Helm Field Guides. 256 pages. GBP 24.99 Paper.

Birds of Peru. By Daniel F. Lane, John P. O'Neill, Theodore A. Parker III, Thomas S. Schulenberg, and Douglas F. Stotz. 2007. Helm Field Guides. 656 pages. GBP 29.99 Paper.

Raptors: A Field Guide to Survey and Monitoring. By J. Hardey, H. Crick, C. Wernham, H. Riley, B. Etheridge and D. Thompson. Stationery Office (TSO), 71 Lothian Road, Edinburgh EH3 9A2 UK. Scotland. 300 pages. email: esupport@tso.co.uk

***Reptiles and Amphibians of Canada.** By Chris Fisher and Ronald Brooks. 2007. Lone Pine Publishing, 10145 – 81 Avenue, Edmonton, Alberta T6E 1W9 Canada. 208 pages. $18.95.

*** Rodent Societies.** By J. Wolff and P. Sherman (Eds). 2007. University of Chicago Press, 1427 East 60th Street, Chicago, Illinois 60637 USA. 610 pages. U.S.$49 Paper, $125 Cloth.

The New Encyclopaedia of Snakes. By Christopher Mattison. 2007. Cassell Illustrated, 2-4 Heron Quays, London E14 4JP. 272 pages. GBP 30 Cloth.

Native Trees of the Southeast – An Identification Guide. By L. Katherine Kirkman, Claud L. Brown, and Donald J. Leopold. 2007. Timber Press, 133 SW 2nd Avenue, Suite 450, Portland, Oregon 97204 USA. 372 pages. $45.95.

Waterbirds Around the World. By Gerard Boere, Colin Galbraith and David Stroud [*Editors*]. 2007. TSO (The Stationery Office), 71 Lothian Road, Edinburgh EH3 9A2 UK. Scotland. 940 pages. GBP 50.

The Last Wild Wolves. By I. McAllister. 2007. Greystone Books, Suite 201, Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 192 pages. $45 Cloth.

† **Whales and Seals – Biology and Ecology.** By P. H. Fontaine. 2007. Schiffer Publishing Ltd., Lower Valley Road, Atglen, Pennsylvania. 448 pages. U.S.$34.95.

* **Why Don't Woodpeckers Get Headaches?** By M. O'Connor. 2007. Fitzhenry and Whiteside Limited, 195 Allstate Parkway, Markham, Ontario L3R 4T8 Canada. 209 pages. $14.95.

ENVIRONMENT

The Sacred Balance. By D. Suzuki. 2007. Greystone Books, Suite 201 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 320 pages. $22.95 Cloth.

Scaling Biodiversity. By David Storch, Pablo Marquet and James Brown. 2007. Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 8RU. GBP 38.

Climate Change. *Edited by* J. DiMento and P. Doughman. 2007. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 USA. 232 pages. U.S.$19.95 Paper.

What We Know About Climate Change. By K. Emmanuel. 2007. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 USA. 96 pages. U.S.$14.95 Cloth.

Saving Planet Earth. By Tony Juniper. 2007. BBC Books, Random House, 1745 Broadway, 3rd Floor, New York, New York 10019 USA. 256 pages. $39.95 Cloth.

† **Foraging – Behavior And Ecology.** By B. Stephens, J. Brown and R. Ydenberg. 2007. University Chicago Press, 1427 E. 60th Street, Chicago, Illinois USA. 608 pages. U.S. Cloth.

The Great Lakes – The Natural History of a Changing Region. By W. Grady. 2007. Greystone Books, Suite 201, Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 320 pages. $49.95 Cloth.

MISCELLANEOUS

* **Beneath My Feet: the Memoirs of George Mercer Dawson.** By Phil Jenkins. 2007. McClelland & Stewart Ltd., 75 Sherbourne Street, 5th Floor, Toronto, Ontario M5A 2P9 Canada. 368 pages. $34.99 Cloth.

Modelling for Field Biologists and Other Interesting People. 2007. By Hanna Kokko. Cambridge University Press, 32 Avenue of the Americas, New York, New York. 230 pages. GBP 27.99.

The World Without Us. By Alan Weisman. 2007. St. Martin's Press, 175 5th Avenue New York, New York 10010 USA. 324 pages. U.S.$24.95 Cloth.

News and Comment

Marine Turtle Newsletter (114)

October 2006. 32 pages: EDITORIALS: Editorial (H. H. Godfrey and L. M. Campbell) — Revision of the Kemp's Ridley Recovery Plan (C. W. Caillouet, Jr.) — Sea turtle subpopulations and the IUCN Red List: A complementary role for conservation genetics (E. Naro-Maciel and A. Formia) — Commentary: What is a subpopulation? (N. Mrosovsky) — ARTICLES: Transatlantic migration of juvenile Loggerhead Turtles from the Strait of Gibraltar (D. Cejudo, N. Varo-Cruz, A. Liria, J. J. Castillo, J. J. Bellido, and L. F. Lopez-Jurado) — On the occurrence of Columbus Crabs (*Planes minutus*) from Loggerhead Turtles in Florida, USA (M. G. Frick, K. L. Williams, M. Bressette, D. A. Singewald, and Richard M. Herren) — Hawksbill Turtle tracking as part of initial sea turtle research and conservation at Groote (S. D. Whiting, S. Hartley, S. Lalara, D. White, T. Bara, C. Maminyamunja, and L. Wurramarrba) — Lower nesting success of Flatback Turtles caused by disorientation (A. U. Koch and M. L. Guinea) — IUCN-MTSG Quarterly report — MEETING REPORTS — LETTER — BOOK REVIEWS — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is now edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. The Managing Editor is Michael Coyne, A321 LSRC, Box 90328, Nicholas School of the Environment and Earth Sciences, Duke University, Durham, North Carolina 27708-0328 USA. Fax +44 1392 263700. Subscriptions and donations towards the production of the MTN can be made online at www.seaturtle.org/mtn or postal mail to Michael Coyne (Managing Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA (e-mail: mcoyne@seaturtle.org).

Canadian Association of Herpetologists/Association Canadienne des Herpetologistes Bulletin Fall 2006

14(1) 28 pages. CONTENTS: Instructions for authors — EDITORIAL: On the return of CAH/ACH — A message from the editor — MEETINGS: CARCNet 2006 Meeting Announcement (Pat Gregory) — JMIH 2006 (Leslie Lowcock) — CAH/ACH Membership and Executive meetings (Jacqueline Litzgus) — FEATURE ARTICLE: On the origins and dispersal of Neotropical rattlesnakes in South America (Adrian Quijada-Mascarenas and Wolfgang Wuster) — FIELD NOTES: Interesting nesting behaviour of Wood Turtles (*Glyptemys insculpta*) (William Greaves) — NEW FACULTY IN HERPETOLOGY AT CANADIAN UNIVERSITIES: Gabriel Blouin-Demers, University of Ottawa; David Lesbarreres, Laurentian University; Jacqueline Litzgus, Laurentian University — THESIS ABSTRACTS IN CANADIAN UNIVERSITIES: Karine Beriault, M.Sc. 2005; Joseph Crowley M.Sc. 2006; Amanda Duffus M.Sc. 2006; Raymond Saumure Ph.D. 2004; Sara Wick M.Sc. 2004 — RECENT PUBLICATIONS IN CANADIAN HERPETOLOGY: Citations 2005-06 — ANNOUNCEMENTS: Former CAH/ACH President Michael Rankin remembered (Francis Cook) — MEMBERSHIP FORM.

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Wildlife Afield 3 (1 and Supplement to 1)

Volume 3, Number 1, contains FROM THE EDITOR: Coming together — On the covers — FEATURE ARTICLE: Supplement to *Wildlife Afield*: Roads and wildlife — NOTES: American Avocets breeding at Bechers Prairie near Riskke Creek, British Columbia in 2005 and 2006 (Phil Ranson) — Manx Shearwater in British Columbia: comments on a pioneering seabird (Michael Force, Ken Morgan, and Jukka Jantunen) — A noteworthy record of the Pigmy Short-horned Lizard (Glenn R. Ryder, R. Wayne Campbell, and Lawrence Powell) — Cactus traps California *Myotis* in British Columbia (Christian W. Gronau) — Whip-poor-will *Caprimulgus vociferus*: a new species for British Columbia, 1968-2006 (Adrian Dorst) — Status of the Yellow-breasted Chat in the Creston Valley, British Columbia, 1968-2006 (R. Wayne Campbell and Edward McMackin) — Unusual mortality of a male Rufous Hummingbird in Burton, British Columbia (Arthur Schoeddert) — Common Raven steals and caches eggs of the Double-crested Cormorant in the Creston Valley, British Col-

umbia (Linda M. Van Damme) — Impact of Cooper's Hawk predation on a nesting colony of Brewer's Blackbirds on Vancouver Island, British Columbia (R. Wayne Campbell and Barbara Begg) — Golden Eagle attacks and kills yearling Mountain Goat (Barbara Zettergreen) — Skeletal remains of the Northern Flicker with a gross bill deformity discovered in a popular tree cavity (Sherry L. Lidstone) — WILDLIFE DATA CENTRE: — Featured species — Common Nighthawk (R. Wayne Campbell, Martin K. McNicholl, R. Mark Brigham, and Janet Ng) — Report of the Wildlife Data Centre: 1 January 2006 to 30 June 2006 (Michael I. Preston) — BRITISH COLUMBIA ROUND-UP: Tips for the field — Field notes for caring people — Errata — News of friends — Life membership — a personal commitment to wildlife — From the Archives — Final Flight — Announcements, Publications of Interest — Volume 3(1), (and Supplement to 3(1), contains: FROM THE EDITOR: At a crossroads — On the covers — ROADS & WILDLIFE: Collisions with wildlife: An overview of major wildlife vehicle collision data collection systems in British Columbia and recommendations for the future (S. Gayle Hesse) — A comparison of roads and rivers as barriers to animal movements: implications for roads in protected areas (Joanna Preston) — High incidence of vehicle-induced owl mortality in the lower mainland and central Fraser Valley, British Columbia (Michael I. Preston and Gerry A. Powers) — A study on the incidence of amphibian road mortality between Ucluelet and Tofino, British Columbia (Barbara Beasley) — Mitigation efforts to reduce mammal mortality on roadways in Kootenay National Park, British Columbia (Michael I. Preston, Larry Halverson and Gayle Hesse) — Using wildlife vehicle collision data, expert opinion and GPS technology to more accurately predict and mitigate vehicular collisions with wildlife in northern British Columbia (Roy V. Rea, Eric K. Rapaport, Dexter P. Hodder, Michael V. Hurley and Nicole A. Klassen) — Road watch BC: A program for collecting, centralizing, and synthesizing information from vehicle-induced wildlife mortalities in British Columbia (R. Wayne Campbell and Michael I. Preston) — Estimating the probability of potential vehicle collision from birds cross roads in interior British Columbia (Michael I. Preston and Joanna Preston) — USEFUL RESOURCES: Books — Symposia, Proceedings, Handbooks, and Reports — Websites — Upcoming meetings — Book review: Road ecology — Road watch BC — Wildlife collision prevention: Hints for the highway.

Details on membership can be obtained from the Biodiversity Centre for Wildlife Studies, PO Box 6218, Station C, Victoria, British Columbia V9P 5L5 Canada. Tel/Fax: 250-477-0465; e-mail: editor@wildlifebc.org; web site: www.wildlifebc.org.

Errata *The Canadian Field-Naturalist* 120(2)

Table of contents outside back cover:
Conservation evaluation of Dwarf Wolly-heads, *Psilocarphus brevissimus* var. *brevissimus*, in Canada
GEORGE W. DOUGLAS, JENIFER L. PENNY, and KSENIA BARTON
"Wolly-heads" should read Woolly-heads.

Article page 235:
First record of a River Otter, *Lontra canadensis*, captured on the northern coast of Alaska
SHAWN P. HASKELL
In abstract and citation "*Lutra*" should be *Lontra*.

Errata *The Canadian Field-Naturalist* 120(3)

Table of contents outside back cover:

Recent invasion, current status, and invasion pathway of European Common Reed, *Phragnites australis* subspecies *australis*, in the southern Ottawa District
PAUL M. CATLING and SUSAN CARBYN
"*Phragnites*" should read *Phragmites*.

Pacific Hagfish. *Eppptatretus stoutii*, Spotted Ratfish, *Hydrolagus colliei*, and scavenger activity on tethered carrion in subtidal benthic communities off western Vancouver Island
SARAH DAVIES, ALI GRIFFITHS, and T. E. REIMCHEN
"*Eppptatretus*" should read *Eptatretus*

The Ottawa Field-Naturalists' Club Awards for 2005

Irwin M. Brodo, Christine Hanrahan, Beverly McBride, and Eleanor Zurbrigg

At the Club's Annual Soirée, held on 29 April 2006, at St. Basil's Church in Ottawa, awards were once again given to members, and two non-members, who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. For the first time in several years, we had a recipient of the Anne Hanes Natural History Award, and the Mary Stuart Education Award was given for the second time. The following citations for those who received an award were read to the members and guests assembled for the event.

Gillian Marston and Suzanne Deschenes – Members of the Year

The OFNC's Member of the Year award recognizes the member(s) judged to have contributed the most to the club during the previous year. Education and Publicity Committee members Gillian Marston and Suzanne Deschenes have made stellar accomplishments over the past year in developing educational and publicity materials for OFNC, and leading a successful membership drive through publicity efforts. They have also brought their considerable computer skills to modernize the Club's photo library and displays.

Gillian and Suzanne are the driving force behind the OFNC's new photography contest which began in 2005 and is set for a second round in 2006. Meant to encourage people's appreciation of nature through photography, and to boost the club's library of digital photographs on natural themes, the first contest reaped 275 images, all of which have the potential to be used in displays or slideshows. The contest resulted in a professional, stunning slide show for the 2006 Annual Business Meeting. All these new images are now catalogued in a digital library, also developed and managed by Suzanne and Gillian. This library is the successor to the club's long-standing and well used slide collection.

Suzanne and Gillian together bring a special synergy of creativity and management skills. They further applied their talents in 2005, taking the club's new image collection to the public by designing and constructing several portable exhibits to highlight Ottawa nature, the club's activities, and to attract new members. Members and non-members alike will recall seeing volunteers staffing these exhibits at the entrance to popular nature walk areas such as the Britannia Conservation Area. They also appeared on site for various club excursions and conferences where they successfully attracted a good number of new members and caught the eye of educators. Gillian and Suzanne and the rest of the committee continue to develop more portable exhibits and to refine the design. For example, they put together a set of slide shows on different themes that can be shown at exhibits using a table-top projector or laptop computer.

Gillian and Suzanne, the club is grateful for your many special contributions during 2005. Designating you as members of the year is our way of saying "thank you"!

Christine Hanrahan – George McGee Service Award

Most successful organizations have a handful of members that devote themselves, body and soul, to the workings of the group, serving on committees, on Council, and in any way that they are needed to make the Club succeed. Christine Hanrahan is one of these people. The Ottawa Field-Naturalists' Club has benefited from her efforts and devotion for over 25 years, and we recognize these efforts with the George McGee Service Award. This award honours members who have volunteered their time to the betterment of the Club over several years. The award commemorates George McGee, who for more than three decades actively devoted much of his spare time to teaching people about birds and natural history through his talks and numerous outings.

Christine has been a member of the OFNC since the late 1970s. She has been an active member of many Club committees, including the Fletcher Wildlife Garden Committee, Conservation Committee, Bird Committee, and Awards Committee. On top of this, she has recently coordinated the local group working on the Ontario Breeding Bird Atlas, which is now drawing to a close. Co-ordinating over a hundred volunteers for 5 years (plus an additional start-up trial year, plus the final data compilation/coordination in 2006) is no small feat. Not only was there all the coordination between Atlas headquarters and the region's 24 volunteers, which included distributing information packages, forms, CDs and other material, but also there were the annual meetings to coordinate, the annual reports to write, the articles for *Trail & Landscape*, and hours and hours spent on-line writing e-mail messages and checking the data of the central database. And this is the *second time* Christine has done this! She was the lead

coordinator in region 24 for the first Atlas project 20 years ago. After that she coordinated the Loggerhead Shrike survey in this area.

But our members probably know Christine best through her work on the Fletcher Wildlife Garden Committee over many years. She has diligently kept long-term and short-term lists of many of the FWG occupants and visitors (e.g., birds and butterflies). This includes preparing the current sightings board and the checklists. She has published many articles in *Trail & Landscape* about the activities and happenings at FWG. She has prepared posters, many pamphlets, checklists, nesting reports, etc., if not solely, then as the main driving force. She has organized many important activities at the Centre to draw in and educate visitors. Every year she has prepared the FWG display and organized the hosting (including herself) at the National Capital Region Wildlife Festival. She has also prepared displays at other events such as the Health Canada-sponsored Environment Day.

Christine has represented the OFNC and the FWG on the National Capital Wildlife Festival Committee for many years and puts a huge amount of time into organizing workshops and conservation awards. The workshops she has organized have been on topics of great interest to the OFNC, such as Invasive Alien Species, conservation (Protecting Wild Places) and bird conservation.

Another of Christine's favourite activities is the OFNC Conservation Committee. She has participated in many committee activities and battles including, most recently, the Larose Forest issue. Here she worked on developing checklists of the flora and fauna with various specialists. She also worked for hours and hours with Ghislaine Rozon reviewing documents, preparing strategy, briefs, writing letters, attending all kinds of meetings in an effort to save the forest from development. Her work on conserving Petrie Island also had a major impact. Working with The Friends of Petrie Island, she compiled lists, wrote articles for *Trail & Landscape*, organized field trips, as well as attending endless meetings, reviewing documents, and preparing OFNC responses. There have been many other conservation issues around Ottawa that have received Christine's attention and hard work, including: Moffat Farm, Montfort Woods, Nortel Woods, Leitrum wetlands, 5309 Bank Street (Tomlinson quarry) and Ferguson Forest. The list seems endless.

And who among us has not read, enjoyed and learned from Christine's many articles in *Trail & Landscape*. She has published on birds, plants, habitats and a wide range of conservation issues. Her short article on snags and old logs is a well known, authoritative and influential document. It has been reproduced and widely distributed within the Ontario Ministry of Natural Resources and has been used and cited by people even in other parts of the world. Her article on hedgerows and their importance to wildlife is another gem and has become an important resource for ecologists. Since the OFNC has been on the Internet, Christine has been an active contributor to our website with informative and interesting material on a variety of natural history subjects.

Because Christine has also served as a knowledgeable member of the Awards Committee for a number of years, recognizing all her achievements and work with an appropriate prize "slipped through the cracks". Not until her nomination came from outside the committee by a number of members all wondering how she could have been overlooked so long could we make this presentation. The Club is therefore pleased to present Christine Hanrahan with this long overdue and well-deserved Service Award.

Friends of the Carp River – Conservation Award (Non-Member)

The OFNC Conservation Award, non-member, is given to a group or individual who has made an outstanding contribution in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

The Friends of the Carp River have worked for many years to protect and restore the ecosystem of the Carp River, and this dedication makes them very worthy recipients of this award.

The Friends of the Carp River grew out of the West Carleton Township's Environmental Advisory Committee which began an extensive study of the Carp River in 1993. The organization was formed in 1997 as a citizen's group whose goal was to help restore and improve the health of the Carp River. The river has its headwaters just south of the Corel Centre and flows 42 km to the Ottawa River at Fitzroy Harbour, and is "the only river that flows entirely within the boundaries of the City of Ottawa". Over the years the river has suffered from shoreline erosion, siltation, flooding, low oxygen levels and subsequent loss of important wildlife habitat. Working with various groups, including landowners, businesses, government agencies and recreational users, the Friends are developing some substantial, achievable goals to continue rehabilitating the "ribbon of life", their wonderfully descriptive term for the Carp River.

Studies show that the Carp River has suffered overall degradation, including silting problems due in part to agricultural tilling practices and channelization. Shoreline erosion further contributes to siltation, which puts at risk the 40 species of fish inhabiting the river. Tributaries of the Carp River have severely degraded water quality due largely to agricultural fertilizers and animal wastes. In spring 2006, the threat of development in the floodplain could bring more problems such as future flooding as well as damaging restoration projects.

The Friends of the Carp River, an entirely volunteer-run organization, is dedicated to reversing the decline

of the river and the Friends have already made tremendous improvements. The Friends have planted over 20 000 trees and shrubs since 1997 with the help and cooperation of local landowners living along the river and many volunteers, and this will have a substantial positive impact on controlling erosion and siltation. With assistance from provincial foresters, site plans for tree planting have been created.

The Friends have worked with the City of Ottawa on its Watershed study, and gathered support from the Ottawa Stewardship Council and the Rural Clean Water Program. Their work was recognized with a Trillium Foundation grant of $50 000 to help them achieve their goal of rejuvenating the Carp River. One of their objectives for this grant was to commission a study of the river, which they did, and the *Carp River Remediation Project report* was prepared by consultants in April 2003.

The Friends of the Carp River have produced a pamphlet which details ways and means for landowners to achieve best management practices. The Friends are available to help steer farmers and others to specific programs, including funding, to enable them to implement improvements that benefit both landowners and the river.

The Friends have been ingenious, creative and tireless in coming up with ways to garner support for the river. Believing that an "image change" for the river was a necessary part of creating a positive public perception, they held a year-long photography contest that encouraged people to submit photos of the Carp River, and also persuaded them to look at the river as a thing of beauty . Winning entries were used to create a Millennium calendar, *Flowing into the next Millennium: A year in the life of the Carp River*, which was sold at cost and sold out in three months. The photos were also used to create sets of notecards, again sold at cost.

A benefit concert with Terry Tufts and Kathryn Briggs was held on Earth Day, 2001 to help raise funds for continued work on the river. A CD of a song, *The Mighty Carp* by Dan Mayo, inspired by the river and dedicated to the Friends was released in 2002.

The Friends explain that "shorelines are breeding grounds, nurseries, food sources, shelter, and hiding places for many species. Ninety per cent of all living things in a lake or river are found along the shoreline. Shorelines are effective natural filters and buffer zones, acting as the 'kidneys' for the watershed. Shorelines help to improve the quality and quantity of ground water. Polluted run-off is trapped and absorbed by the vegetation, thus protecting water quality. The complex interplay of plants, animals, land, and water combine to make the shorelines the single most important part of the river ecosystem."

The Friends have been remarkably successful in drawing the community into active involvement with the health of the river as evidenced not only by the many volunteers who turn out for tree-planting activities but by the tremendous support they have received from local businesses and granting agencies. For these reasons and more, the OFNC is very pleased to give the Friends of the Carp River this year's Conservation Award for non-members.

Iola Price – Conservation Award (Member)

The OFNC Conservation Award is given in recognition of a club member who has made an outstanding contribution towards protecting our natural environment. Iola Price is a very worthy recipient of this award in recognition of her effective membership in the City of Ottawa's Forest and Greenspace Advisory Committee (OFGAC) to promote conservation of trees and forests.

As the current Chair of the Ottawa Forests and Greenspace Advisory Committee, and co-chair before that, Iola provides an articulate and credible voice on issues related to conservation of the trees, forests and greenspace of our Nation's capital.

The Ottawa Forests and Greenspace Advisory Committee was established in the fall of 2001 to advise Ottawa City Council and provide a forum for citizens on issues related to trees and forests. Iola's accomplishments include reviewing OFGAC position papers before transmission to appropriate authorities, preparation of numerous written briefs and making powerful submissions to city committees. For example, Iola recently exhorted City Council at a budget planning meeting to "think of trees as green infrastructure, as essential to a well-ordered city as sewers, lighting and roads".

On many occasions, Iola has made a powerful and persuasive intervention during the City's planning process in support of the importance of greenspace and protection of sites of urban natural ecological significance. Her recent interventions regarding the Nepean Creek Corridor as well as her efforts for improving the criteria utilized for determining appropriate urban density development levels underscores this dedication towards the maintenance and protection of trees and greenspace in the National Capital Region (NCR).

Iola has provided recommendations to strengthen ecological provisions in urban design studies such as Riverside South Community Design and Leitrim Community Design. She spearheaded opposition to development projects such as the highly controversial Carp Ridge housing project and the Phase 2 Leitrim Wetlands development, which, if approved, would extend housing into the wetland itself.

Iola is recognized as a very effective and valuable "networker", regularly liaising with other tree and greenspace-oriented community groups operating in the NCR. This includes our Club through the Conservation Committee and Fletcher Wildlife Garden. Members of these committees wholeheartedly appreciate that Iola

is very quick and efficient in replying to queries and in exploring issues and ideas, which helps so much when it allows one to continue one's work without delay.

Through this award, OFNC members recognize the outstanding efforts towards protecting our natural environment by one of our members – Iola Price.

Macoun Field Club – Anne Hanes Natural History Award

The Anne Hanes Natural History Award, named in honour and memory of one of the Club's most dedicated amateur naturalists, is made in recognition of a member who, through independent study or investigation, has made a worthwhile contribution to our knowledge, understanding and appreciation of the natural history of the Ottawa Valley. The award is designed to especially recognize work that is done by amateur naturalists.

The OFNC feels that there can be no more worthy recipient than the Macoun Field Club in recognition of the remarkable studies the members of the MFC have made of the Macoun Study Area in Bells Corners over a 35 year period, documenting rare plants and animals, tracking changes to plant and animal populations as well as the environment, producing and up-dating vegetation maps of the area, and much more. The MFC, sponsored jointly by the OFNC and Canadian Museum of Nature, has been a haven for youngsters interested in nature since 1948, and accepts members from grades 4 through 12.

The idea of having a special area of natural land designated as a "study area" for members of the Macoun Field Club came from the senior (high school) members, not from the adult leadership. The first study area in the Bells Corners area was actually where the Wild Bird Centre is now, but because the OMNR was cutting out the dead and dying elms at the time, they suggested an area across the road in a less disturbed site west of Moodie Drive. Within two years, the members had drawn a vegetation map of most of the 800 acres making up the site. This valuable base map was based on aerial photographs supplemented by field trips to determine what was there. There have been several versions made to keep pace with changes: 1972, 1986, 1992, and 2000. A colour version was created for the Club's web site (www.magma.ca/~rel/mfc/studyarea/msa.html). In this way, the MFC members traced the changes that occurred in a significant part of the Ottawa Greenbelt brought on by urbanization, beaver activity, tree diseases and people. The MFC members, on their bi-weekly field trips over many years, mostly led by Rob Lee, created lists of trees (54 species), wildflowers, birds, mammals (29 species), reptiles and amphibians, and lichens (215 species). In the process, they discovered many rarities and have documented the disappearance of certain species. Their studies continue on everything from "the sand grains in the soil" to "Leatherwood Treehoppers."

Because each member is encouraged to "adopt a tree" and study its growth and health, its inhabitants in the crown, on the trunk and at its base, the MFC has amassed an amazing amount of information about seasonal fluctuations in a suburban forest system.

Much of this information has been organized on the MFC's amazing website designed and maintained by Rob Lee, but the information itself was gathered by the members. It is improbable that any urban greenspace in Canada has such a well-documented history of its flora and fauna.

Observations on the Macoun Study Area have been regularly published by the members in their annual magazine, *The Little Bear*, and, because of the Internet, is now readily available to the general public as well. Most important, the experience that the members have gained in doing careful field research has encouraged many past members to embark on a career in conservation biology, botany, zoology, park management or teaching.

The OFNC feels that the Macoun Field Club members have done a remarkable job, under the leadership of Rob Lee, and well deserves the Anne Hanes Natural History Award.

Michael Léveillé – Mary Stuart Education Award

The Mary Stuart Education Award was established to recognize members, non-members or organizations for their outstanding achievements in the field of natural history education in the Ottawa Region. Michael Léveillé, a science teacher at the Educarium, an Ottawa private school, is without doubt a natural history educator par excellence, and a most worthy recipient of this Award.

Michael has taught at the Educarium since 1996. His passion for nature is infectious and inspirational and is observed most keenly by his students. Michael brings an impressive background to his role as science teacher. He founded the Ottawa Paleontology Society in 1991 to advance an understanding of fossils. He has long been associated with the Canadian Museum of Nature where he created a number of popular programs, most notably the "Collector's Corner", a museum discovery centre. At the museum he worked with people of all ages, instilling an awareness of, and appreciation for, the natural world. However, there is no doubt that Michael excels at working with young people, encouraging them to be attuned to the rhythms of the natural world around them.

Michael is also an accomplished artist with a degree in Visual Arts from the University of Ottawa. His work has been exhibited at local universities, museums, as well as at the Educarium. Michael was the artist for the children's storybook series "Fergi the Frog".

Under Michael's knowledgeable direction, in 2004 his students designed and implemented the "Macoun Marsh Project" at Beechwood Cemetery, to demonstrate how a thriving and diverse ecosystem can exist inside a large urban centre. This became one of their most ambitious and high profile projects, and is ongoing. Because the marsh was unnamed when they began working on it, they held a "Marsh Naming Contest" and encouraged neighbours and the community at large to join in. Overwhelming support led to naming it after John Macoun (1831-1920) who is buried at Beechwood. The contest, and the work done by the students, led to increased public awareness of the site and eventually resulted in the Directors of Beechwood Cemetery making a firm commitment to protect and maintain it.

The Macoun Marsh project encourages students to study the marsh over different seasons. They are taught to record scientific observations in journals, identify and study the different species found, and learn the fundamentals of ecology. They also design, construct, install and maintain bird feeders at the site. Under Michael's careful instruction, the Educarium students have documented nearly 900 species at the marsh.

The project has grown beyond their wildest expectations. Funding to continue with studies and enhancements has been obtained from a variety of sources including the Wetland Habitat Fund and the City of Ottawa. In conjunction with the Beechwood Cemetery Foundation, plans are underway for habitat enhancement, a boardwalk, and an outdoor classroom in spring 2006. The students continue to keep nature journals and will present this work at various venues around the city over the coming year. Michael invited the neighbouring Jean Vanier Catholic School to join his students on the project, and in May 2006 both schools sent representatives to Göteborg, Sweden, for the Volvo Adventure International contest for natural history projects.

Michael's inspired teaching guarantees that his students will continue to be engaged by the world of nature, and so it is for this most important work, that OFNC is pleased to present Michael Léveillé with the Mary Stuart Education Award for 2005.

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Advice for Contributors to *The Canadian Field-Naturalist*

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COVER: "When Blackfeet and Sioux Meet" 1908 oil painting by Charles M. Russell (1864–1926). Courtesy of Sid Richardson Museum where the original is housed. Born in St. Louis, Missouri, Charles M. Russell went west to Montana as a boy of 16 with a dream of becoming a real cowboy. Beginning in 1882, Charlie worked on various cattle drives wrangling horses where he quickly established a reputation as a likeable cowboy who loved to draw and paint. During his 11 years on the range, he witnessed the changing of the West as the days of free grass and unfenced range were ending. Charlie quit the cowboy way of life in 1893 and married Nancy Cooper three years later. With Nancy's keen business sense and belief in her husband's talent, Russell's paintings began to be known nationally. Charlie Russell felt deeply the passing of the West, the most evident theme of his art. The old ways of Indian and cowboy life had disappeared. His works reflected the public's demand for authentic pictures of the West, yet the soul of his art was romance. (Jan Scott, Director, Sid Richardson Museum, 309 Main Street, Fort Worth, Texas 76102 USA; e-mail: jan@sidricharsonmuseum.org) See article by Charles M. Kay "Were native people keystone predators: A continuous-time analysis of wildlife observations made by Lewis and Clarke in 1804-1806" pages 1–16.

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Were Native People Keystone Predators? A Continuous-Time Analysis of Wildlife Observations Made by Lewis and Clark in 1804-1806

Charles E. Kay

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Kay, Charles E. 2007. Were native people keystone predators? A continuous-time analysis of wildlife observations made by Lewis and Clark in 1804-1806. Canadian Field-Naturalist 121(1): 1–16.

It has long been claimed that native people were conservationists who had little or no impact on wildlife populations. More recently, though, it has been suggested that native people were keystone predators, who lacked any effective conservation strategies and instead routinely overexploited large mammal populations. To test these hypotheses, I performed a continuous-time analysis of wildlife observations made by Lewis and Clark because their journals are often cited as an example of how western North America teemed with wildlife before that area was despoiled by advancing European civilization. This included Bison, Elk, Mule Deer, Whitetailed Deer, Blacktailed Deer, Moose, Pronghorn Antelope, Bighorn Sheep, Grizzly Bears, Black Bears, and Grey Wolves. I also recorded all occasions on which Lewis and Clark met native peoples. Those data show a strong inverse relationship between native people and wildlife. The only places Lewis and Clark reported an abundance of game were in aboriginal buffer zones between tribes at war, but even there, wildlife populations were predator, not food-limited. Bison, Grizzly Bears, Bighorn Sheep, Mule Deer, and Grey Wolves were seldom seen except in aboriginal buffer zones. Moose were most susceptible to aboriginal hunting followed by Bison and then Elk, while Whitetailed Deer had a more effective escape strategy. If it had not been for aboriginal buffer zones, Lewis and Clark would have found little wildlife anywhere in the West. Moreover, prior to the 1780 smallpox and other earlier epidemics that decimated native populations in advance of European contact, there were more aboriginal people and even less wildlife. The patterns observed by Lewis and Clark are consistent with optimal foraging theory and other evolutionary ecology predictions.

Key Words: Native hunting, aboriginal buffer zones, Lewis and Clark, keystone predation, reference conditions, Elk, Bison, Grizzly Bears, Mule Deer, Whitetailed Deer, western North America.

It has long been postulated that native people were conservationists who had little or no impact on wildlife populations (e.g.; Speck 1913, 1939a, 1939b). Studies of modern hunter-gatherers, however, have found little evidence that native people purposefully employ conservation strategies (Alvard 1993, 1994, 1995, 1998a, 1998b; Hill and Hurtado 1996), while archaeological data suggest that prehistoric people routinely overexploited large-mammal populations (Broughton 1994a, 1994b, 1997; Jones and Hilderbrant 1995; Janetski 1997; Butler 2000; Chatters 2004). Elsewhere, I have proposed that native people were keystone predators, who once structured entire ecosystems (Kay 1994, 1995, 1997a, 1997b, 1998, 2002).

To test these competing hypotheses, I performed a continuous-time analysis of wildlife observations made by Lewis and Clark on their expedition across North America in 1804-1806 because their journals are often cited as an example of how the West teemed with wildlife before that area was despoiled by advancing European civilization (Botkin 1995, 2004; Patten 1998: 70; Wilkinson and Rauber 2002; Nie 2003: 1). Lewis and Clark were the first Europeans to traverse what eventually became the western United States, and many of the native peoples they met had never before encountered Europeans. In addition, historians universally agree that Lewis and Clark's journals are not only among the earliest, but also the most detailed and accurate, especially regarding natural history observations (Burroughs 1961; Ronda 1984; Botkin 1995, 2004). Thus, the descriptions left by Lewis and Clark are thought by many to represent the "pristine" state of western ecosystems (Craighead 1998: 597; Patten 1998: 70; Wilkinson and Rauber 2002; Botkin 2004). Botkin (1995: 1), for instance, described Lewis and Clark's journey as "the greatest wilderness trip ever recorded."

Methods and Study Area

Recently, Martin and Szuter (1999a, 1999b, 2002, 2004), Lyman and Wolverton (2002), and Laliberte and Ripple (2003) presented contrasting interpretations of western ecosystems based on Lewis and Clark's journals, but those analyses are flawed, in part, because they either did not separate ungulates by species or they did

not correlate wildlife sightings with the abundance of native people on each day of the entire trip. Instead, I developed three measures to quantify the wildlife observations recorded by Lewis and Clark in their original journals, which have recently been re-edited and republished (Moulton 1986, 1987a, 1987b, 1988, 1990, 1991, 1993 – hereafter cited only by volume and page). First, game seen. If Lewis and Clark reported old sign of a species, that was assigned a value of one, fresh sign a two, and if they actually saw the animal, a three. This included Bison (*Bison bison*), Elk (*Cervus elaphus*), Whitetailed Deer (*Odocoileus virginianus*), Mule Deer (*O. hemionus hemionus*), Blacktailed Deer (*O. h. columbianus*), Moose (*Alces alces*), Pronghorn Antelope (*Antilocapra americana*), Bighorn Sheep (*Ovis canadensis*), Grizzly Bears (*Ursus arctos*), Black Bears (*U. americanus*), and Grey Wolves (*Canis lupus*). This was done each day for the entire 863 days of the expedition.

Second, game killed. On each day, Lewis and Clark recorded the exact number of animals that were killed to provision their party. In three instances, though, Lewis and Clark reported that "some" Whitetailed Deer (day 78), Elk (day 365), or Bison (day 413) were killed. In these cases, "some" was recorded as three animals killed. In 12 instances, Lewis and Clark reported that "several" Whitetailed Deer (days 46, 365, 367, 373, 408, and 811), Bison (days 354, 406, 408, and 413), Mule Deer (day 404), or Blacktailed Deer (day 602) were killed. In those cases, "several" was recorded as seven animals killed. Similar to game seen, the number of animals killed was recorded for all species on all days.

Third, herd size. If Lewis and Clark reported sighting large numbers of a particular animal, a value of ten was assigned to that species on that day. A value of ten was also assigned if Lewis and Clark reported killing 10 or more of one species on a single day. I then added game seen, game killed, and herd size values for all species on each day to obtain a daily measure of wildlife abundance. Again, this was done for all 863 days of the expedition.

I also developed a similar convention to quantify the relative abundance of native people that Lewis and Clark encountered each day of their journey. If Lewis and Clark observed old sign, that was assigned a value of one, fresh sign a two, and if Lewis and Clark actually saw native people, a three. If Lewis and Clark met more than ten native people on a given day that was assigned a value of ten. On most days Lewis and Clark traveled together but on a few occasions they took separate routes, most notably on the return trip. In those cases, Lewis' observations were recorded separately from Clark's. These conventions produced nearly 40 000 numerical data entries. To facilitate analysis, Lewis and Clark's route was divided into 55 trip segments (Table 1), for which mean daily abundances of wildlife and mean daily abundances of native people were calculated. It should be noted that Lewis and Clark generally sent their best hunters ahead of the main party so that game would more readily be encountered.

Lewis and Clark left St. Louis, Missouri on 14 May 1804 and proceeded, via watercraft, up the Missouri River through present-day Missouri, Kansas, Nebraska, Iowa, South Dakota, and into North Dakota where they built Fort Mandan in close proximity to the Mandan and Hidatsa villages. Lewis and Clark over-wintered at Fort Mandan, and then ascended the Missouri River into present-day Montana during the spring of 1805. After leaving their larger boats and portaging the Great Falls, Lewis and Clark continued up the Missouri to Three Forks before ascending the Jefferson and Beaverhead Rivers, on whose upper reaches they met the Shoshone. After obtaining horses from the Shoshone, Lewis and Clark cached their canoes where Clark Canyon Reservoir is now situated and traveled over the Continental Divide into Idaho and down the Lemhi and Salmon Rivers. From there, Lewis and Clark ascended the North Fork of the Salmon and crossed Lost Trail Pass, re-entering Montana.

Next, Lewis and Clark traveled down the Bitterroot Valley to Lolo Creek, which they traced to its source. Lewis and Clark then followed the high ridges north of Idaho's Lochsa River and eventually descended to the lower Lochsa, where the explorers met the Nez Perce. At this point, Lewis and Clark left their horses and proceeded via canoe down the Clearwater, Snake, and Columbia Rivers through present-day Oregon and Washington state. Finally, Lewis and Clark built Fort Clatsop and overwintered on the south bank of the Columbia near the Pacific Ocean.

During the spring of 1806, Lewis and Clark retraced their route, with minor variations, until the expedition reached present-day Lolo, Montana, where the party divided. Lewis ascended the Blackfoot River, crossed the Continental Divide, and proceeded to the Great Falls on the Missouri River, where the party split a second time. Lewis left most of his men to repair the boats cached in 1805, while he and three companions traveled by horseback to Cutbank Creek, where they met the Blackfeet. After the only fatal encounter with native people on the entire trip, Lewis retreated to the Missouri, where he rejoined the rest of his men and together they floated down that river until reunited with Clark below the Yellowstone in present-day North Dakota.

Clark, on the other hand, left Lolo, Montana, and ascended the Bitterroot River to Chief Joseph Pass, where he entered the Big Hole. From there, Clark crossed to the Beaverhead and refloated the canoes cached in 1805. Clark's party then proceeded by land and water to Three Forks, where the group split a second time. Clark sent some of his men and the canoes down the Missouri to meet Lewis at Great Falls, while he traveled overland via Bozeman Pass to the Yellowstone. At this point, Clark fashioned canoes and floated down the Yellowstone and Missouri Rivers until reunited with

TABLE 1. Trip segments and itinerary of Lewis and Clark 1804-1806.

Trip segment	Segment length (days)	Description	Dates
1	30	St. Louis to Grand River, Missouri	5/14-6/12/1804
2	50	Grand River to Council Bluffs, Nebraska	6/13-8/1/1804
3	20	Council Bluffs to Big Sioux River, Nebraska	8/2-8/21/1804
4	4	Big Sioux River to above Vermillion River, Nebraska	8/22-8/25/1804
5	8	Above Vermillion River	8/26-9/2/1804
6	22	Above Vermillion River to Bad River, South Dakota	9/3-9/24/1804
7	22	Bad River to below the Cannonball River, North Dakota	9/25-10/16/1804
8	7	Cannonball River to Mandan Villages, North Dakota	10/17-10/23/1804
9	9	Mandan Villages, North Dakota	10/24-11/1/1804
10	156	Fort Mandan, North Dakota	11/2/1804-4/6/1805
11	6	Fort Mandan to Little Missouri River, North Dakota	4/7-4/12/1805
12	13	Little Missouri River to Yellowstone River, North Dakota	4/13-4/25/1805
13	12	Yellowstone River to Milk River, Montana	4/26-5/7/1805
14	12	Milk River to Musselshell River, Montana	5/8-5//19/1805
15	14	Musselshell River to Marias River, Montana	5/20-6/2/1805
16	13	Marias River to Great Falls, Montana	6/3-6/15/1805
17	29	Great Falls portage	6/16-7/14/1805
18	10	Great Falls to Three Forks, Montana	7/15-7/24/1805
19	13	Three Forks to Big Hole River, Montana	7/25-8/6/1805
20	6	Big Hole River to meeting Shoshone in Idaho – Lewis' account	8/7-8/12/1805
21	14	Present Clark Canyon Reservoir across divide to Lemhi River, Idaho – Lewis' account	8/13-8/26/1805
22	16	Above Three Forks to present Clark Canyon Reservoir, Montana – Clark's account	8/1-8/16/1805
23	12	Clark Canyon Reservoir to Lemhi River to Salmon River and return to Lemhi – Clark's account	8/17-8/28/1805
24	13	Lemhi River, Idaho, to present Lolo, Montana	8/29-9/10/1805
25	9	Lolo, Montana, over Lolo Trail to lower Lochsa River, Idaho	9/11-9/19/1805
26	17	Lower Lochsa River – canoe camp	9/20-10/6/1805
27	18	Canoe Camp to the Dalles, Washington	10/7-10/24/1805
28	9	Cascade Mountains and portage, Washington	10/25-11/2/1805
29	22	Cascade Mountains to the mouth of Columbia River on the north bank, Washington	11/3-11/25/1805
30	11	Crossed to south bank of the Columbia River, Oregon	11/26-12/6/1805
31	106	Ft. Clatsop, Oregon	12/7-3/22/1806
32	15	Ft. Clatsop to the Cascade Mountains, Washington	3/23-4/6/1806
33	12	Cascade Mountains to the Dalles, Washington	4/7-4/18/1806
34	25	The Dalles to Camp Chopunnish, Idaho	4/19-5/13/1806
35	27	Camp Chopunnish, Idaho	5/14-6/9/1806
36	15	Attempted crossing of mountains	6/10-6/24/1806
37	5	Crossed mountains on Lolo Trail	6/25-6/29/1806
38	3	Present Lolo, Montana – here Lewis and Clark separated	6/30-7/2/1806
39	5	Lewis – up Blackfoot River and across Continental Divide, Montana	7/3-7/7/1806
40	14	Lewis – Divide to Great Falls (split party) Lewis to Cutbank Creek, Montana	7/8-7/21/1806
41	6	Lewis – Upper Cutbank Creek, met Piegan, fled back to Missouri River	7/22-7/27/1806
42	11	Lewis – Marias River down Missouri to Yellowstone River, North Dakota	7/28-8/7/1806
43	4	Lewis – Down Missouri until reunited with Clark	8/8-8/11/1806
44	10	Clark – Lolo, Montana, up Bitterroot into Big Hole Valley then to present Clark Canyon Reservoir and down to Three Forks where the party again split	7/3-7/12/1806
45	3	Clark – Three Forks to Bozeman Pass and on to the Yellowstone River, Montana	7/13-7/15/1806
46	18	Clark – Down Yellowstone River to Missouri River, North Dakota	7/16-8/2/1806
47	9	Clark – Down Missouri River until reunited with Lewis, North Dakota	8/3-8/11/1806
48	6	Little Missouri River to Mandan Villages to Ft. Mandan, North Dakota	8/12-8/17/1806
49	3	Heart River to Cannonball River, North Dakota	8/18-8/20/1806
50	2	Aricara villages, South Dakota	8/21-8/22/1806
51	7	Moreau River to White River, South Dakota	8/23-8/29/1806
52	5	White River to Vermillion River, Nebraska	8/30-9/3/1806
53	5	Big Sioux River to Council Bluffs, Nebraska	9/4-9/8/1806
54	9	Platte River to Grand River, Missouri	9/9-9/17/1806
55	6	Grand River to St. Louis, Missouri	9/18-9/23/1806

Lewis. Lewis and Clark then descended to St. Louis (2: 64; 3: 6; 4: 6; 5: 6, 110, 176; 6: 6, 80; 7: 6; 8: 8-9, 49, 84).

Results

Lewis and Clark's observations show an inverse relationship between wildlife and native people (Figure 1). Wildlife was abundant only where native people were absent, and if it had not been for the presence of aboriginal buffer zones between tribes at war (Hickerson 1965; Steffian 1991; Martin and Szuter 1999a, 1999b, 2002, 2004; Farr 2001; Laliberte and Ripple 2003), there would have been little wildlife anywhere in the West.

Yankton Sioux buffer zone

As Lewis and Clark ascended the Missouri River, they met the Omahas and Ottes on day 97 and the Yankton Sioux on day 108 (Figure 2). These two groups were at war (2: 488), and wildlife was abundant only in the buffer zone between the tribes. Bison, in particular, were found only in the center of the buffer zone.

Sioux-Mandan buffer zone

Lewis and Clark met the Teton Sioux on day 135, the Arikaras on day 148, and the Mandan-Hidatsa on day 164. Wildlife was not abundant in the area between the Teton Sioux and the Arikaras, but was abundant between the Arikaras and the Mandan-Hidatsa (Figure 3). This was because the Teton Sioux and Arikaras were allied against the Mandan-Hidatsa (3: 156, 161, 195-196, 207, 226, 233-234, 243-244, 251, 272-273, 295-297, 304-305; Porsche and Loendorf 1987; Bouchet-Bert 1999). That is, peace had a negative impact on wildlife populations while war had a beneficial effect, similar to conditions Hickerson (1965) reported in the upper Mississippi Valley (Farr 2001).

Missouri-Yellowstone buffer zone

In 1804-1806 all of Montana between the Missouri and Yellowstone Rivers was a six-sided buffer zone between warring tribes (4: 21-22, 67, 108-109, 159-160, 216, 222, 354, 379, 401, 426, 437; 5: 8-9, 45, 68-71, 77-80, 85, 87-91, 96-97, 102-106, 123-124, 178, 197, 259, 318; 7: 242, 250; 8: 88, 93-94, 104, 113, 123, 143, 182, 195, 278, 321, 323). The north was controlled by the Blackfeet Confederation, which consisted of five tribes (Ewers 1958), while on the west were the Flathead, Salish, Kootenay, and their allies. The Shoshone occupied the southwest (Trenholm and Carley 1964), the Crow the south-central, and the Sioux, Cheyenne, and their allies the southeast. To the east were the Mandan, Hidatsa, and their allies (Ahler et al. 1991). Within this large buffer zone (Martin and Szuter 1999a, 2002, 2004; Farr 2001), wildlife was relatively more abundant (Figures 4-7) because the warring factions did not hunt along the Yellowstone and Missouri as frequently as they did more secure environments closer to each tribe's core area. As noted by Lewis and Clark, tribes did venture into the buffer zone,

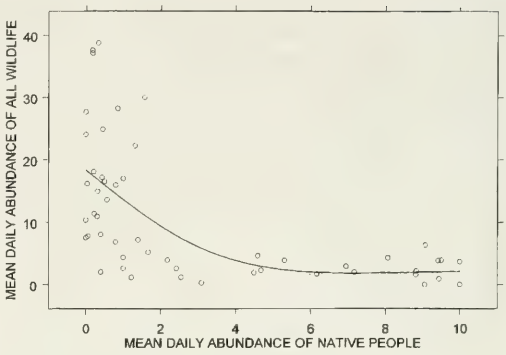

FIGURE 1. Relationship between the abundance of native people and the abundance of wildlife as observed by Lewis and Clark in 1804-1806. Plotted are the mean daily abundance of all wildlife species and the mean daily abundance of native people by trip segments – segments 1, 2, 54, and 55 were excluded because those areas were near European settlements. Line fitted using a smoothing spline with cross validation (Mathsoft 1997: 158-167). X and Y axes are offset. Note that there are no data points in the upper right as might be expected if cultural beliefs fostered conservation. Clearly, it made little difference what native people believed, or said they believed. Instead, aboriginal hunting followed predictions derived from optimal foraging theory and other evolutionary ecology models.

but only in force due to fear of attack. So the Missouri-Yellowstone buffer zone was not unhunted (4: 232), instead the area was just hunted less frequently (Farr 2001), which apparently was sufficient to permit greater numbers of wildlife.

Deer

Lewis and Clark killed more Whitetailed Deer than all other large mammals combined. By comparison, Mule Deer were rare and were found only in tribal boundary zones, while blacktails were restricted to the Cascade Mountains west to the Pacific (6: 328, 331, 403-404). Even along the lower Columbia, though, Lewis and Clark encountered more whitetails than blacktails. This was because whitetails had a more effective escape strategy than the other deer (Geist 1998; Whittaker and Lindzey 2001; Lingle 2002; Robinson et al. 2002) and thus were less affected by native hunting. Even where native people were abundant, some whitetails were usually able to survive (Figure 8a) because, when discovered, whitetails quickly fled into riparian thickets from which they could not easily be dislodged (5: 87; 6: 403). Lewis and Clark noted that Mule Deer and Elk when chased fled into the open (4: 136-137; 6: 403), making those species easier to hunt.

Elk

Lewis and Clark reported that Elk were easier to kill than Whitetailed Deer (6: 85, 242), which is reflected in the fact that native hunters had a greater impact on

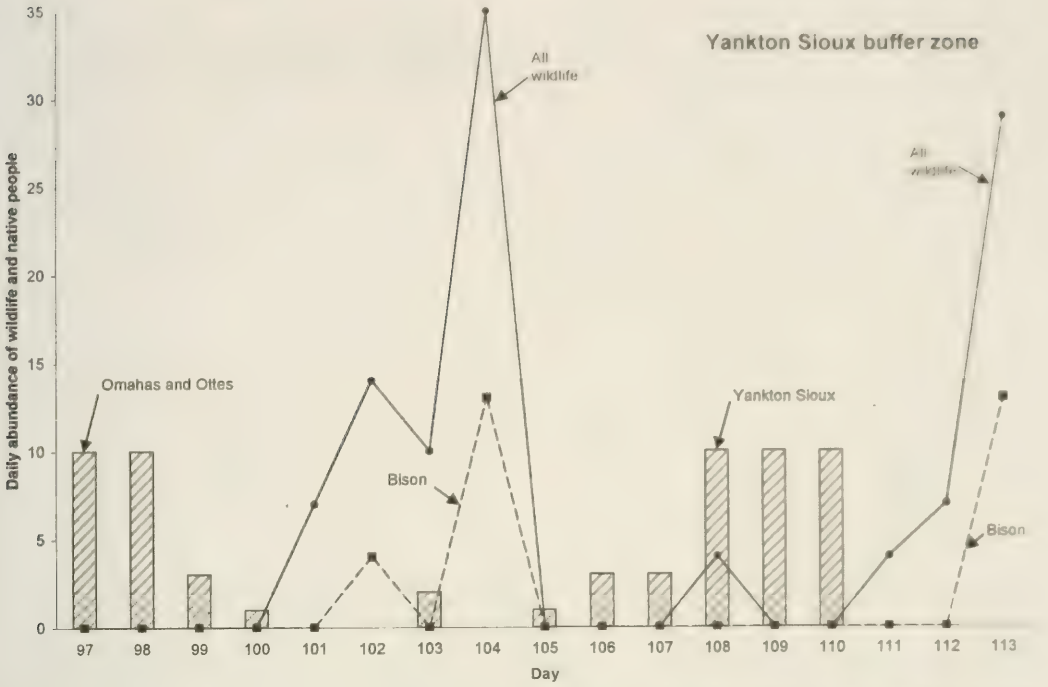

FIGURE 2. Yankton Sioux buffer zone along the Missouri River as reported by Lewis and Clark in 1804. Wildlife was abundant only in the zone between warring tribes.

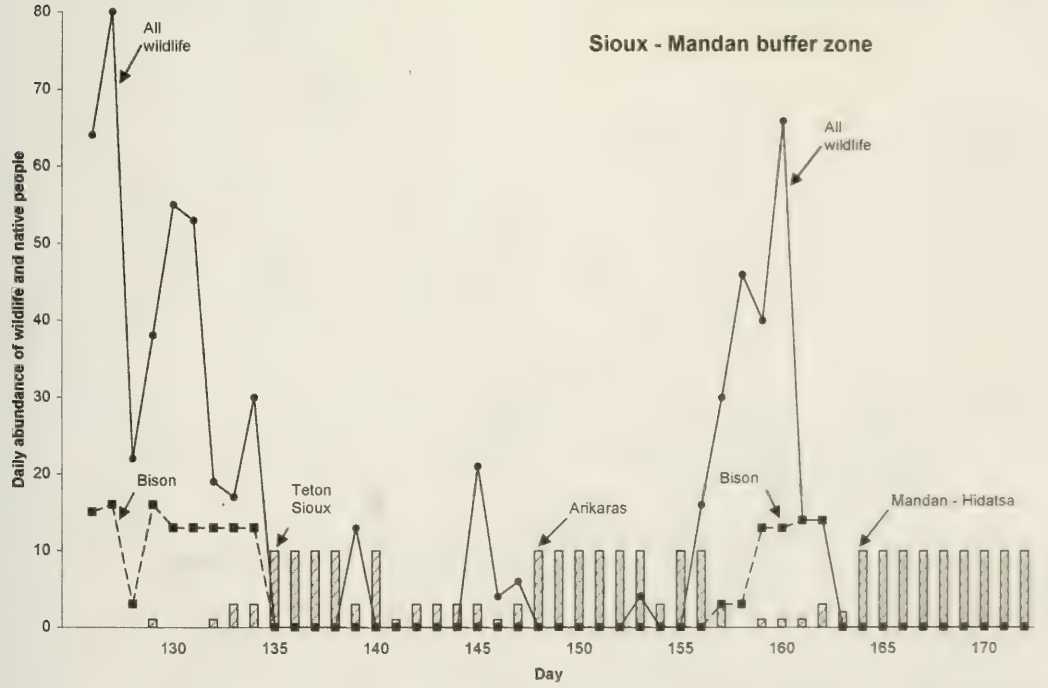

FIGURE 3. Sioux-Mandan buffer zone along the Missouri River as reported by Lewis and Clark in 1804. The Teton Sioux were allied with the Arikaras against the Mandan-Hidatsa and wildlife was abundant only in the zone between warring factions. There was little wildlife and no Bison in the area between the allied tribes.

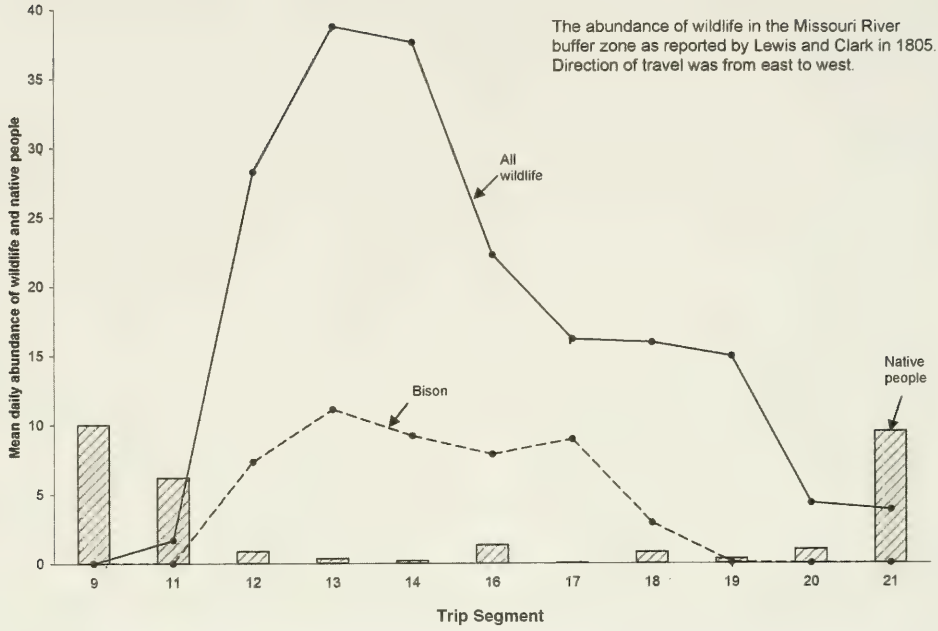

FIGURE 4. The mean daily abundance of wildlife and native people along the Missouri River buffer zone as reported by Lewis and Clark in 1805. On their trip across this section of Montana, Lewis and Clark did not see a single native person from the time they left the Mandan (trip segments 9 and 11) until they met the Shoshone along the Montana-Idaho border (trip segment 21). Bison were observed only where native people were absent.

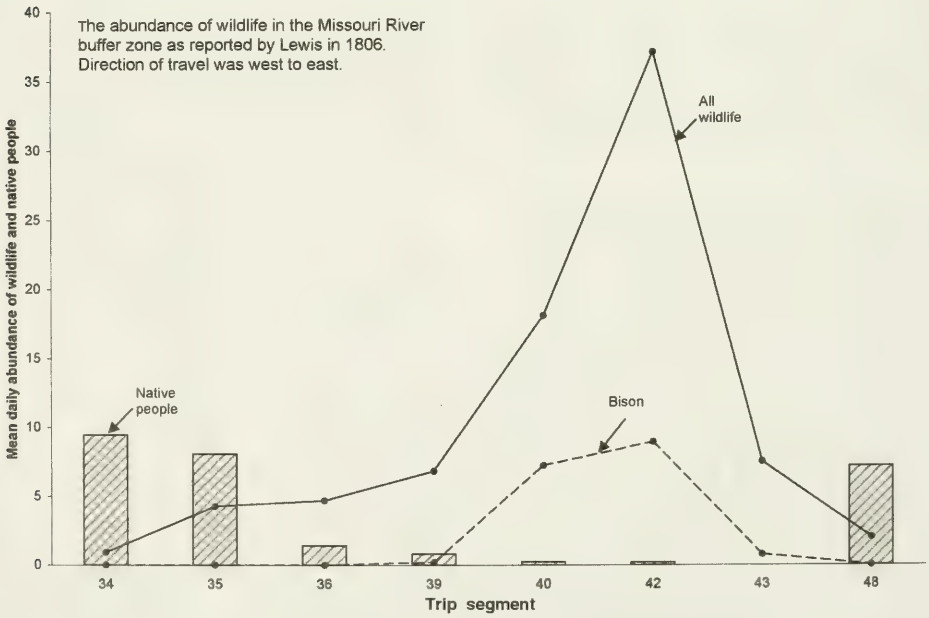

FIGURE 5. The mean daily abundance of wildlife and native people along the Missouri River buffer zone as reported by Lewis in 1806. Trip segment 34 included tribes in central Washington, while Lewis and Clark spent trip segment 35 with the Nez Perce. Lewis and Clark then crossed the Bitterroot Mountains (trip segment 36) and separated at Lolo, Montana. By trip segment 40, Clark was back at Great Falls on the Missouri River, which he descended to the Mandan villages (trip segment 48). As on the upstream journey (Figure 4), Clark did not see a single native person on this section of the Missouri and wildlife was abundant only where native people were absent. Bison, in particular, occurred only in the center of the buffer zone.

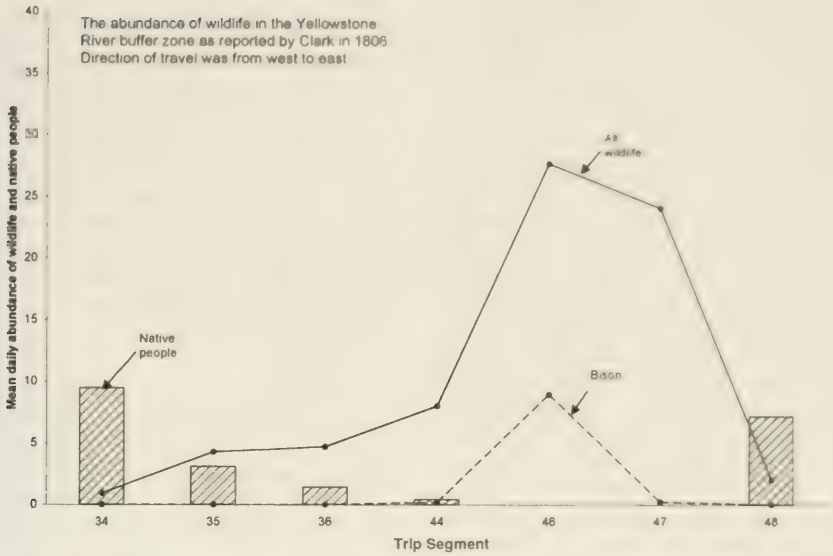

FIGURE 6. The mean daily abundance of wildlife and native people along the Yellowstone River buffer zone as reported by Clark in 1806. Trip segments 34, 35, and 36 are the same as those in Figure 5. After Lewis and Clark separated, Clark returned to Three Forks by trip segment 44 and was on the Yellowstone River by trip segment 46. Although the Crow stole all of Clark's horses on the Yellowstone, he did not actually see a single native person on his return trip across Montana until he neared the Mandan villages (trip segment 48). The only place wildlife was abundant was along the Yellowstone River and Bison were only seen in the center of that buffer zone.

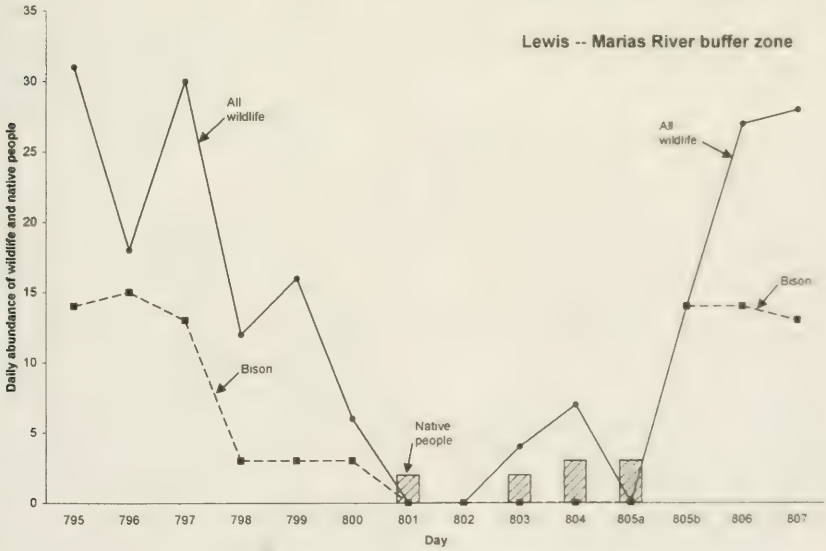

FIGURE 7. Marias River buffer zone. After returning to Great Falls, Lewis ascended the Marias River and Cutbank Creek in what is now the Blackfeet Indian Reservation. As Lewis traveled from the Missouri, wildlife became less and less abundant, while Bison disappeared. Wildlife was reported on days 803 and 804 only because Lewis sent his hunters downstream 30-40 km to kill Whitetailed Deer for food. On day 804 Lewis met seven Blackfeet who told him their village was less than one-half day's travel. Lewis camped with this small group of Blackfeet and next morning (day 805a) awoke to find the Blackfeet attempting to steal his guns and horses. An altercation followed and at least one Blackfoot was killed, the only native person killed by Lewis and Clark on their entire journey. Fearing retaliation and annihilation, Lewis fled back to the Missouri, and by his own account, traveled more than 160 km by nightfall (day 805b). Thus within one day's hard travel, Lewis went from an area with no game and native people to an area with abundant game and no natives. Bison were found only where native people were absent (8: 112-140).

the abundance of Elk (Figure 8b) than they did deer (Figure 8a). Lewis and Clark did kill a number of Elk at Fort Clatsop, but only because they purposefully built the fort where Elk were relatively more common and native people infrequent (6: 92-93, 95-96, 105, 108, 112). That is, Lewis and Clark constructed Fort Clatsop in an intervillage buffer zone to take advantage of the more abundant Elk. Nevertheless, Lewis and Clark observed that most of the Elk they killed during the winter of 1805-1806 had old arrow wounds (6: 208, 210), indicative of intense native hunting. "Many of the Elk we have killed since we have been here, have been wounded with these arrows, the short piece with the barb remaining in the animal and grown up in the flesh" (6: 208). Lewis and Clark also described how native people used pit traps to kill Elk. "Then pits are employed in taking the Elk, and of course are large and deep, some of them a cube of 12 or 14 feet. These are usually placed by the side of a large fallen tree, which as well as the pit [lie] across the [trails] frequented by the Elk. [The] pits are disguised with the slender boughs of trees and moss; the unwary Elk in passing the tree precipitates himself into the pit which is sufficiently deep to prevent his escape" (6: 208). Thus, even in thick coastal forests, Elk were intensely hunted by native people.

Pronghorn Antelope

Native hunting had an even greater impact on the abundance of Pronghorn Antelope (Figure 8c). Despite their great speed, pronghorns were relatively easy for native people to kill (3: 176; Frison 1991).

Bison

Native hunting controlled the distribution and number of Bison on the northern Great Plains (Figure 8d). The only places Lewis and Clark saw Bison, and especially in large numbers, were in the center of aboriginal buffer zones between warring tribes. This is similar to what West (1995) documented on the central Great Plains – if it had not been for warring tribes and buffer zones, there would have been few Bison anywhere in North America (Kay 2002).

Bighorn Sheep

Native hunting had an even greater effect on Bighorn Sheep (Figure 8e). Lewis and Clark reported an abundance of bighorns only in the center of buffer zones far removed from native people.

Grizzly Bears

Native hunters also controlled the distribution and abundance of Grizzly Bears (Figure 8f). This is similar to what Birkedal (1993) reported in Alaska. Aside from a few grizzlies killed in the rugged Idaho mountains, Lewis and Clark only observed grizzlies in aboriginal buffer zones.

Black Bears

Based on Lewis and Clark's observations and kill rates, Black Bears were less common than grizzlies, even in forested areas.

Moose

Despite spending substantial amounts of time in what is currently prime Moose habitat, Lewis and Clark recorded Moose only once (6: 313; 7: 326; 8: 95) and that was in the center of the buffer zone between the Blackfeet and the Flathead-Salish. As explained elsewhere, native hunting controlled the distribution and abundance of Moose throughout western North America (Kay 1997b). Contrary to what is generally believed, Moose are more abundant in western North America today (Stevens 1971; Pierce and Peek 1984) than they were in Lewis and Clark's time, or any other point in the past (Kay 1997b).

Grey Wolves

Lewis and Clark observed a direct relationship between the abundance of game and the abundance of wolves. Wolves were common only where game was relatively abundant (4: 85). Thus, wolves were largely restricted to the same aboriginal buffer zones as were Bison, Elk, and other ungulates.

Dogs and horses

I also recorded the number of dogs (*Canis familaris*) Lewis and Clark purchased when game was in short supply, and the number of horses (*Equus caballus*) the explorers killed for food. Lewis and Clark killed nine horses and bought (ate) 210 dogs, primarily in the Columbia Basin, where native people were particularly abundant and wildlife was virtually non-existent (7: 49, 92). Lewis and Clark also bought large quantities of other foodstuffs from various native peoples, especially corn from the Mandan-Hidatsa and salmon from tribes throughout the Columbia Basin.

Discussion

Optimal-foraging theory

According to optimal-foraging theory, high-ranked diet items are more susceptible to overexploitation than lower-ranked items (Smith 1983; Stephens and Krebs 1986; Smith and Winterhalder 1992; Butler 2000). Theoretical considerations and studies of modern hunter-gatherers both indicate that large mammals are the highest-ranked diet items, and that, in general, the larger the animal, the higher its rank (Smith and Winterhalder 1992; Hill and Hurtado 1996). Moreover, if risk to the hunter or travel distances are great, only the highest-ranked diet items should be pursued (Smith and Winterhalder 1992). Thus, optimal-foraging theory would predict that when native people entered aboriginal buffer zones, they should have concentrated their hunting on the larger species, such as Bison and Elk, causing those species to decline accordingly. This would also imply that native people lacked any effective conservation strategy regarding these prey items. This pattern was, in fact, observed by Lewis and Clark as they left various native peoples and entered buffer zones, first Whitetailed Deer increased, then Elk and then Bison. Conversely, as Lewis and Clark exited a buffer zone, Bison disappeared first, followed by Elk, while

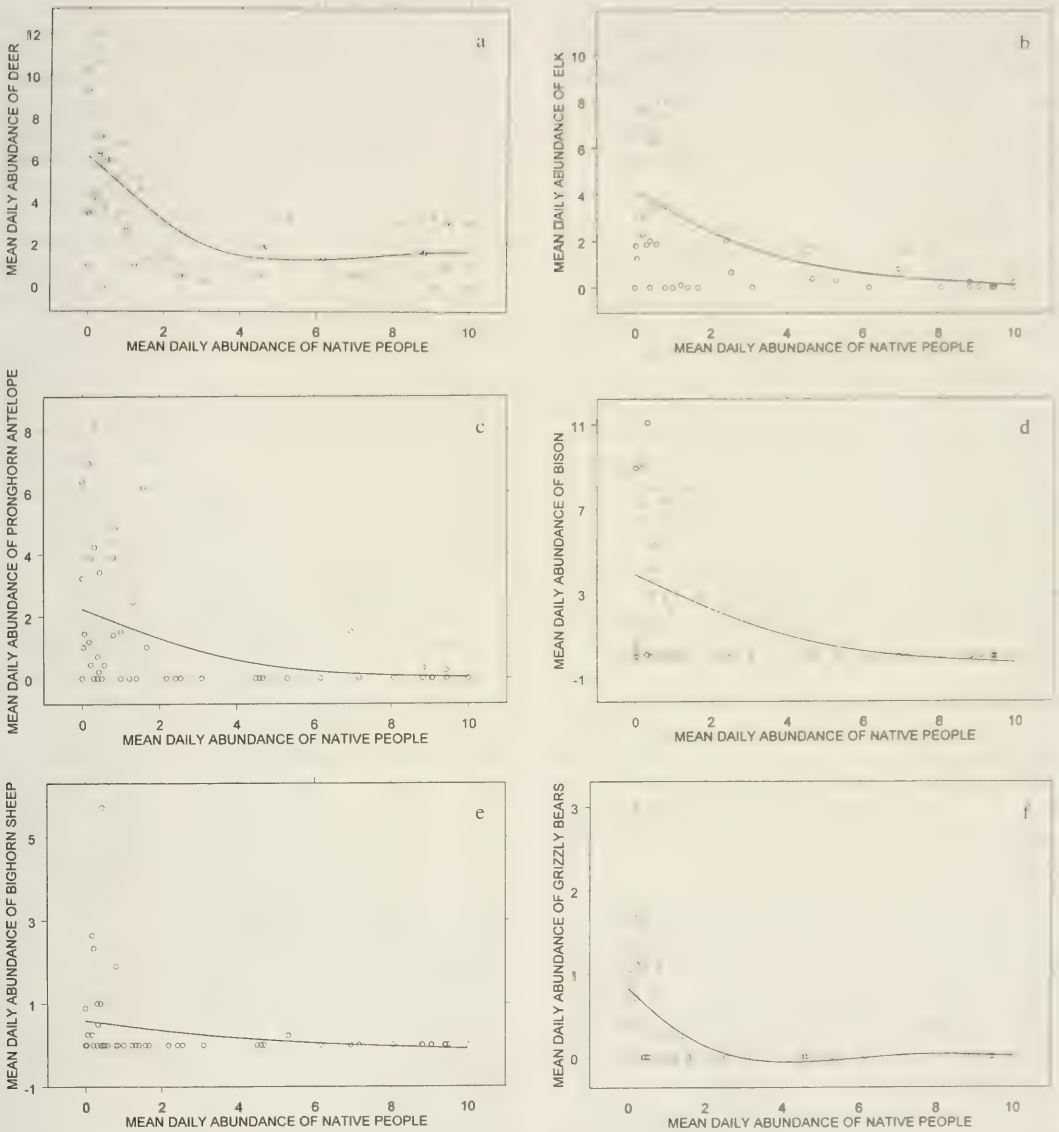
a
MEAN DAILY ABUNDANCE OF DEER
MEAN DAILY ABUNDANCE OF NATIVE PEOPLE
b
MEAN DAILY ABUNDANCE OF ELK
MEAN DAILY ABUNDANCE OF NATIVE PEOPLE
c
MEAN DAILY ABUNDANCE OF PRONGHORN ANTELOPE
MEAN DAILY ABUNDANCE OF NATIVE PEOPLE
d
MEAN DAILY ABUNDANCE OF BISON
MEAN DAILY ABUNDANCE OF NATIVE PEOPLE
e
MEAN DAILY ABUNDANCE OF BIGHORN SHEEP
MEAN DAILY ABUNDANCE OF NATIVE PEOPLE
f
MEAN DAILY ABUNDANCE OF GRIZZLY BEARS
MEAN DAILY ABUNDANCE OF NATIVE PEOPLE

FIGURE 8. Relationship between the abundance of native people and the abundance of various wildlife species as observed by Lewis and Clark in 1804-1806. Plotted are the mean daily abundance of species and the mean daily abundance of native people by trip segments – segments 1, 2, 54, and 55 were excluded because those areas were near European settlements. Lines fitted using a smoothing spline with cross validation (Mathsoft 1997: 158-167). X and Y axes are offset. (a) Whitetailed Deer, (b) Elk, (c) Pronghorn Antelope, (d) Bison, (e) Bighorn Sheep, and (f) Grizzly Bears.

some Whitetailed Deer were usually able to escape native hunters (Figure 9). Furthermore, Lewis and Clark noted that native hunters preferred to kill female ungulates (3: 61, 270) due to that sex's higher fat content. Now, killing females runs counter to any conservation strategy (Kay 1994, 1997b, 1998; Kay and Simmons 2002).

Alvard (1998b, 2002) recently reviewed the conditions under which evolution by natural selection might favor resource conservation by humans. In short, conservation will be favored by evolution only if the resource is economical to defend. For instance, if 1000 kcal are spent defending a resource, but less than 1000 kcal are derived from that resource, evolution will not favor conservation. For a variety of reasons, including competition from carnivore predators, large mammals were seldom, if ever, economical to defend (Kay 1994, 1998, 2002). Instead the logical, rational thing to do was to kill-out the large mammals as quickly as possible and then move on to other resources,

which is exactly what aboriginal people did (Kay 1998, 2002). Counter-intuitively, once that was accomplished, native populations actually increased because people were forced to consume lower-ranked, but more abundant diet items (Hawkes 1991, 1992, 1993). There is also an evolved discount rate that acts to negate a wide range of possible conservation practices (Rogers 1991, 1994).

Predator-limited

Even within buffer zones, though, wildlife was not as abundant as one might think, because the animals were predator, not food, limited (Kay 1998, 2002). Food-limited ungulates invariably destroy berry-producing shrubs and woody riparian vegetation due to repeated browsing, and once willows (*Salix* spp.), cottonwoods (*Populus* spp.), and aspen (*Populus tremuloides*) decline, so do associated species like Beaver (*Castor canadensis)* (4: 189-190), which are dependent upon those plants for food (Kay 1998 and references therein; Nietvelt 2001). Lewis and Clark, however, reported that riparian thickets were common in buffer zones, as were Beaver and berry-producing shrubs (e.g.; 4: 70, 145-146, 189-190, 247, 278, 332, 374, 391-392, 399, 414, 419, 428, 435, 451; 5: 14, 42, 46, 59). In addition, Lewis and Clark noted that Whitetailed Deer often had twin fawns or triplets, and that even lactating deer were fat (4: 165), which would not have been physiologically possible if ungulate populations had been food-limited. Thus, carnivore predation and occasional hunting by native people (4: 232) kept buffer zone ungulate populations well below what the habitat could otherwise support (White et al. 1998; Kay 2002).

Estimate of pre-Columbian wildlife populations

A number of investigators have cited Lewis and Clark's descriptions of abundant wildlife without realizing that those accounts only apply to the center of buffer zones (Craighead 1998; Wilkinson and Rauber 2002). Botkin (1995: 49-86; 2004: 141-147), for instance, used Lewis and Clark's observations of grizzlies along the Missouri and Yellowstone Rivers to estimate the number of bears in the western United States prior to European contact, and arrived at a figure of 56 000, which others increased to 100 000 for the entire continent (e.g.; Flores 1998: 61). Although Botkin (1995: 165-169) acknowledged that native people could be important ecological factors, he failed to realize that native hunting controlled the distribution and numbers of grizzlies throughout North America (Figure 8f; Birkedal 1993). During pre-Columbian times, there may have been no more than 4000-5000 grizzlies in all of North America because the bears were simply large packages of fat meat that native hunters killed at will (Hallowell 1926: 31-37; Birkedal 1993). Similarly, there never were 60 million Bison on the Great Plains (Seton 1929; Roe 1951), as is commonly believed (Shaw 1995; Geist 1996; Kay 2002).

Canadian buffer zones

Aboriginal buffer zones also occurred throughout western Canada. Palliser, for instance, reported that "As a general rule the more dangerous the country [due to Indian attack] the greater the probability of finding [an] abundance of game, showing in more ways than one the truth of the old sportsman's adage the more danger the more sport. This part of the country is so evidently the line of direction [demarcation] between the three hostile tribes, that none of them dare venture into it for hunting, except when driven to desperation by hunger, they endeavor to snatch their game from between the jaws of Scylla and Charybdis. Much therefore as I enjoyed [this] locality for a hunting camp, seeing buffalo on all sides, elk feeding in the distance, and fresh deer tracks in every direction... Boucharville [Palliser's companion] did not relish it at all, and began already to calculate how soon we were to go away" (Palliser 1969: 266-267). "The abundance of game here [and not anywhere else] is accounted for by its being the neutral ground of the Crees, Assineboines, and Blackfeet; none of these tribes are in the habit of resorting to its neighborhood except in war parties.... We are now in the heart of the buffalo country. This region may be called a buffalo preserve, being the battle-ground between the Crees and the Blackfeet..." (Spry 1968: 146). Like Lewis and Clark, Palliser observed grizzlies primarily in aboriginal buffer zones.

Alexander Henry the Younger, describing conditions on the Red River, also noted that grizzlies were found almost exclusively in aboriginal buffer zones – "they [grizzlies] are – very numerous, and seldom are molested by the hunters [Indians], it being the Frontier of the Sieux [sic] and their enemy where none can hunt in safety. Here they [the bears] breed and multiply in the greatest security" (Gough 1988: 72). While Henry Hind (1971: 28-29) reported the presence of five aboriginal buffer zones on the northern Great Plains – four in Canada and one in the United States. "The following are celebrated 'war-paths,' where hunting is generally disallowed although game from that circumstance is usually more abundant. 1. 'The War-path River' and war road of the Lac la Pluie, Ojibways and the Sioux, from Rainy River to Red Lake River, thence across the prairies in the Valley of Red Lake River to Miniwahen or Devil's Lake, in Dakotah [sic] Territory. 2. 'War-path River,' from the southwest corners of Lake of the Woods to Roseau River, thence to the prairies west of Red River – same tribes. 3, 'War-path River', from Lake Winnipeg to the Little Sashatchewan [sic], thence to the prairies south of Manitobah [sic] Lake – the old war-path of the Swampy Crees, the Assinaiboines and Sioux, also of the Swampy Crees and the Lake Winnipeg Ojibways. 4. The 'war-road' near the Elbow of the South Branch of the Sashatchewan [River], on the flanks of the Grand Coteau, of the Blackfeet and Plain Crees. 5. The 'war-road' of the Sioux, Blackfeet and

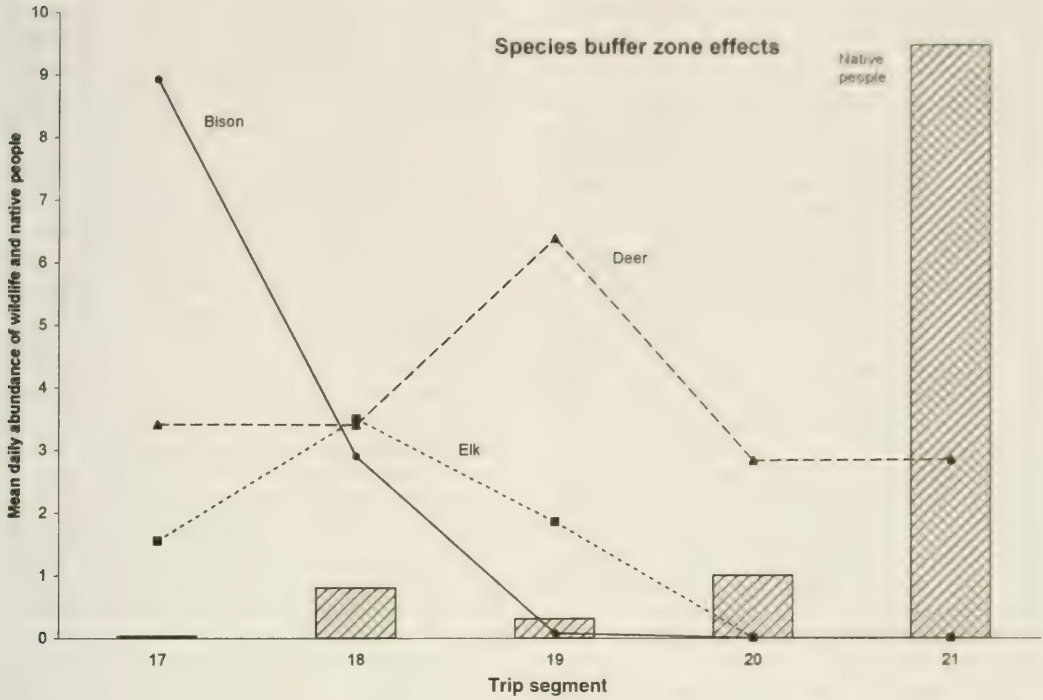

FIGURE 9. The effect of native hunting on Bison, Elk, and Whitetailed Deer. As Lewis and Clark ascended the Missouri River from Great Falls (trip segment 17) and finally met the Shoshone (trip segment 21), wildlife became less and less abundant. First, Bison disappeared, and then Elk, until only a few Whitetailed Deer remained. This is the pattern that would be expected if native hunters foraged optimally without regard to conservation.

Crows, in the Valley of the Yellowstone [River]". In addition, both Alexander Mackenzie and Samuel Black noted the presence of an aboriginal buffer zone along the lower Peace River in northern British Columbia (Rich 1955: 112; Lamb 1970: 279, 288-289, 404-407). Similarly, Alexander Mackenzie reported a major Indian-Inuit buffer zone in the far north on his 1789 trip to the Arctic Ocean (Lamb 1970: 181-233) as did Franklin (1969) in 1821-1822.

As in the United States, most observations of wildlife in western Canada recorded by early European explorers, including virtually all sightings of Grizzly Bears, occurred in aboriginal buffer zones. Heretofore these buffer zone observations have been interpreted to mean that all of western Canada once teemed with game, which is simply not true. Instead, many areas of western Canada were almost devoid of wildlife due to intense native hunting (Kay et al. 2000).

Prey behavior

Lewis and Clark also reported a direct relationship between prey behavior and native hunting. In the center of buffer zones, where native people hunted only infrequently, game was relatively tame and could easily be approached (e.g., 4: 67, 108). Elsewhere, however, game was exceedingly wary. "The country about the mouth of this river [Little Missouri] had been recently hunted by the Minetares, and the little game which they had not killed and frightened away, was so extreemly [sic] shy that ... [our] hunters could not get in shoot [range] of them" (4: 26). "The Borders of the river [Missouri] has so much hunted by those Indians ... [that] the game is scerce [sic] and veery [sic] wild" (4: 39). This also applied to Grizzly Bears and other animals. "[The bears] appear more shy here [near the Shoshone] than on the Missouri below the mountains" (4: 426). "These anamals [sic] [beaver] in consequence of not being hunted [in a buffer zone] are extreemly gentle, where they are hunted [though] they [the beaver] never leave their lodges in the day" (4: 100). Similarly, in 1819 Long observed that Bison fled in panic at the mere scent of humans. "The wind happening to blow fresh from the south, the scent of our party was borne directly [to the Bison], and we could distinctly note every step of [our scent's] progress through a distance of eight or ten miles, by the consternation and terror it excited among the buffaloes. The moment the tainted gale infected their atmosphere, [the Bison] ran with as much violence as if pursued by a party of mounted hunters" (Thwaites 1905: 255-256) – not unexpectedly, these observations were made in an aboriginal buffer zone along the Platte River in eastern Colorado (West 1995). This is identical to what Diamond (1984) reported in New Guinea, where even low-intensity aboriginal hunting completely altered the be-

havior of prey species, as well as significantly reducing prey number (Kay 2002).

Habitat

Over the years, I have retraced most of Lewis and Clark's route across North Dakota, Montana, Idaho, Washington, and Oregon, and there are no habitat features that could explain the distribution and abundances of the various species observed by the explorers. Lewis and Clark, for instance, did not find any "buffalo" in the large, treeless valleys of southwest Montana. This they attributed to the fact that Bison had been driven-out and/or killed-out by Shoshone hunters, not habitat characteristics (8: 182). At another point in their journey, Lewis and Clark commented on how they could see no difference between the country west of the mountains and the plains along the Missouri, except that wildlife was common only on the latter. "I see very little difference between the apparent face of the country here [eastern Washington and western Idaho] and that of the plains of the Missouri only that these [the Columbia Basin grasslands] are not enlivened by the vast herds of buffaloe [sic] Elk [etc] which ornament the other" (7: 196). Bighorn Sheep are certainly restricted to areas with precipitous escape terrain, but Lewis and Clark found bighorns common only in the center of aboriginal buffer zones. Other suitable habitat was unoccupied because those areas were more frequently used by native people.

Moreover, there is no evidence to support the assertion by Mack and Thompson (1982) or Lyman and Wolverton (2002) that Bison and other ungulates were rare in the Columbia Basin because those grasslands were nutritionally deficient. First as Daubenmire (1985) and others have noted, the Columbia Basin supported an open range livestock industry for nearly 40 years during the late 1800s (Oliphant 1968; Galbraith and Anderson 1971). Since cattle are less efficient herbivores than Bison, there is no physiological reason Columbia Basin grasslands could have supported large numbers of free-ranging cattle and not Bison (Van Vuren 1987; Urness 1989). In addition, a modern Elk herd on Columbia grasslands not only grew at near the maximum rate of increase for that species, but produced huge record-book antlers, as well – all indicative of excellent nutritional conditions (McCorquodale et al. 1988, 1989; McCorquodale 1991, 1993). Free-ranging Bison on other intermountain ranges have also shown high rates of increase (Van Vuren and Bray 1986; Keiter 1997; Bjornlie and Garrott 2001). There is also no evidence to support the notion that historically Columbia Basin Bison populations were kept at low levels by severe winter weather, as proposed by Daubenmire (1985). After all, Bison thrive in Yellowstone National Park (Keiter 1997; Bjornlie and Garrott 2001) and Wood Buffalo National Park (Carbyn et al. 1998) where winter climates are much more severe than in the Columbia Basin (Urness 1989). Instead, Bison and other ungulates were rare or absent from most of the Columbia Basin because large runs of salmon, and other alternative resources, supported high numbers of native people (Hunn and French 1981), who took their preferred ungulate prey to low levels or local extinction (Kay 1994, 1998, 2002; Chatters 2004).

Native populations and European diseases

It has long been known that native people in the Americas had no immunological resistance to European diseases, but only recently has it been learned that those diseases had a significant impact on native people prior to direct European contact (Dobyns 1983), or how this, in turn, caused abnormal increases in wildlife populations (Neumann 1985; Preston 1996, 1997, 2002; Kay 1998, 2002; Kay and Simmons 2002). European diseases, for instance, preceded Lewis and Clark. The smallpox epidemic of 1780 was especially devastating (Boyd 1985; Trimble 1985), and its aftermath was noted by Lewis and Clark (2: 478-482; 3: 285, 295, 311-312; 6: 81-82, 285, 308). In 1804-1806, Lewis and Clark found four Mandan villages along the middle Missouri but observed that there had been 12 prior to the 1780 epidemic. Similarly, Arikaras villages were reduced from 32 to 2 (Ahler et al. 1991: 57). Thus, if Lewis and Clark had journeyed west in 1775 instead of 1804-1806, they would have met more native people and correspondingly there would have been even less wildlife (Geist 1998: 4-5; Kay 1998, 2002). Furthermore, European diseases may have decimated native populations throughout western North America as early as 1550-1600 (Ramenofsky 1987; Campbell 1990; Kornfeld 1994: 198; Preston 1996, 1997, 2002), which suggests that pre-Columbian wildlife populations were likely much lower than even what Lewis and Clark experienced. Butler (2000), who studied resource depression in the Columbia Basin, reported that high-ranked diet items, such as ungulates, increased only after epidemic diseases decimated native populations ca. 1550. Similarly, Chatters (2004: 72-73) reported that Bison numbers increased only when native populations declined.

Conclusions

Contrary to prevailing paradigms (Lyman and Wolverton 2002; Moore 2002; Wilkinson and Rauber 2002), native people controlled the distribution, abundance, and behavior of wildlife, and large mammals were common only in boundary or buffer zones between warring tribes (Martin and Szuter 1999a, 1999b, 2002, 2004; Farr 2001). It is also clear that Lewis and Clark recognized this phenomenon, for Clark (8: 328) "observed that in the country between the [Indian] nations which are at war with each other the greatest numbers of wild animals are to be found." This pattern can only be explained if native hunters pursued an optimal-foraging strategy and did not employ any effective conservation measures (Alvard 1998b, 2002). Only twice did Lewis and Clark report high wildlife values and encounter

large numbers of native people on the same day. In both cases, native hunters were killing as many animals as possible (3: 176, 253-255). Moreover, Lewis and Clark were only able to complete their journey because of the food, horses, and above all else, knowledge that they received from native people. There were no unnamed streams, there were no unnamed mountains, and there was no wilderness (Kay and Simmons 2002). As noted by Lewis and Clark, the West was even more densely populated prior to the smallpox pandemic that decimated native people in 1780.

These data have important implications for anthropology and archaeology, as well as other disciplines. Most anthropological subsistence models, for instance, incorporate the view that native people harvested ungulates at or near sustained yield levels, yet these and other data do not support that assumption (Kay and Simmons 2002). Similarly, cultural or religious beliefs are often invoked to explain how aboriginal peoples interacted with their environment (Krech 1999), yet irrespective of what the 40 or so native groups encountered by Lewis and Clark believed, or said they believed, the ecological patterns were identical, at least regarding large mammals (see Figure 1). This is similar to what Jerozolimski and Peres (2003) reported for modern subsistence hunters in South America, where neither ethnicity nor culture slowed the depletion of game stocks. Finally, these data support the hypothesis that native people were keystone predators, who once structured entire ecosystems (Kay 1998, 2002; Kay and Simmons 2002); i.e., ecologists need to abandon the myth of once abundant wildlife and instead recognize that unhunted ungulate populations are outside the range of historical variability.

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The Influence of Air Pollution on Corticolous Lichens near the Strathcona Industrial Area, Alberta

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Lichens that grow on the bark of mature trees were studied at 35 sites along an air pollution gradient east of Edmonton, Alberta. Data on species composition, richness, and cover were recorded in October 1999 in a matrix of sites that extends from a known source of pollutants (the Strathcona Industrial Area) east across Strathcona County. Air pollution is affecting the corticolous lichen community. Lichen species richness and total cover increased with distance from the pollution source. Species richness in areas distant from pollution was roughly twice that in areas near the Strathcona Industrial Area. *Xanthoria fallax* and *Phaeophyscia orbicularis* were the most pollution tolerant lichens. *Xanthoria hasseana, Ochrolechia arborea, Physcia adscendens, Parmelia sulcata,* and *Melanelia albertana* were rare or absent near the pollution source and common in more distant areas. Most of the 15 species assessed were sensitive to air quality to some degree. Some lichens near the refineries and in Sherwood Park showed abnormal coloration and poor thallus integrity indicative of stress. We discuss implications for human health.

Key Words: corticolous lichens, air pollution, health, refineries, vehicle emissions, Alberta.

Lichens are well-known indicators of air quality. While most lichen biomonitoring studies have been conducted in Europe and the United States, there is a growing body of such studies in Canada. In western Canada, 49 lichen species have been used to study general air pollution, while 39, 23, and 18 species have been used to monitor sulphur dioxide, photochemicals, and fluoride, respectively (Thormann 2006). Lichens have proven useful to characterize the concentrations and deposition patterns of air pollutants over large areas, particularly for metals, sulphur, and nitrogen compounds (Enns 2001*).

The fungal and algal partners of the lichen symbiosis live in a delicate balance. Any pollutant that affects the well-being of either partner affects the lichen as a whole (Brodo et al. 2001). Sensitivity to air pollution is related to several features of lichens. They obtain nutrients only from air and precipitation; they accumulate compounds in their thalli and have inefficient mechanisms of excluding or eliminating wastes, they have no protective epidermis or cuticle, and they are quick to show symptoms of stress (Case 1981*; USGS 2005*).

The concentration and constituents of air pollution vary in time and space. In Alberta, there are several important constituents and sources of air pollution (Alberta Environment 1996*; Alberta Health and Wellness 2003). Sulphur dioxide (SO_2) is released from natural gas processing plants, oil sands facilities, power plants, gas flaring, oil refineries, pulp and paper mills, and fertilizer plants. In Alberta, 42% of SO_2 is emitted from natural gas processing plants (Myrick and Hunt 1998*). Hydrogen sulphide is released from fugitive emissions (leakages) at petroleum refineries, tank farms for unrefined petroleum products, natural gas and petrochemical plants, oil sands plants, sewage treatment plants, kraft pulp and paper plants, and animal feedlots. Natural sources include sulphur hot springs and some wetlands and lakes.

Nitrous oxides are produced from high temperature combustion of natural gas, coal, oil, and gasoline. Nitrogen dioxide (NO_2) is a pungent toxin. Ozone near ground level comes from reaction of nitrous oxides and volatile organic compounds in the presence of sunlight and from transport of upper atmosphere ozone down to ground level. Ozone levels are generally lower in urban and polluted areas as ozone is destroyed by nitric oxide (NO). Hydrocarbons come from a variety of industrial and natural sources. The most abundant hydrocarbon in the Earth's atmosphere is methane, a potent greenhouse gas. Reactive hydrocarbons such as alkenes, alkynes, and aromatics are toxic to humans and other animals and vegetation. They react with nitrous oxides in the presence of sunlight to form ozone.

Particulates come from a variety of sources (typically combustion) and can act as carriers for biologically active metals and combustion products. Particulate monitoring is based on the mass of particles filtered per m^3 of air; PM_{10} and $PM_{2.5}$ refer to particles <10 µm and <2.5 µm respectively. In Alberta, the ratio of $PM_{2.5}$: PM_{10} in recent years has ranged from 0.52 to 0.59 (Pollution Watch 2006*).

Alberta is the largest emitter of air pollutants in Canada, with a 2005 release of 1.339 billion kg, 28.4% of the national total, an increase of 62% over its 2002 pollutant release (Pollution Watch 2006*). Among the criteria air contaminants that affect human and ecosys-

tem health, Alberta released 412.8 million kg of sulphur dioxide and 403.9 million kg of oxides of nitrogen in 2005 (Pollution Watch 2006*).

Lichens can be harmed by a variety of air pollutants, including sulphur dioxide, sulfuric and nitric acids, ozone, hydrocarbons, fluorides, and metals such as copper, lead, and zinc (Brodo et al. 2001). Sulphur dioxide impacts on lichens have been noted in Europe since the early 19th century (Simonson 1996*) and can cause decreased species richness, diversity and vitality (Case 1981*). Pollution-tolerant lichens may exhibit increased cover in polluted areas because of decreased competition with more sensitive species, such as *Melanelia albertana* (Muir and McCune 1988; Forest Health Highlights 1994*). Comparative study of the lichens in an urban or industrial area with those distant from pollution can provide a good indicator of air quality.

Our objective was to determine if there are spatially detectable effects on the lichen communities of mature tree bark within and downwind of pollution sources. We focused on the corticolous lichen species that grow on Balsam Poplar (*Populus balsamifera*) and Trembling Aspen (*Populus tremuloides*) trunks.

Study Area

The study area and the Strathcona Industrial Area ("Refinery Row", Figure 1) are located east of Edmonton, Alberta. Refinery Row contains a large group of refineries and other industrial plants and is downwind of Edmonton. Sherwood Park, Fort Saskatchewan, and rural Strathcona County are downwind of Refinery Row. Major sources of air pollution from Refinery Row are industrial plants and vehicle emissions (Alberta Environment 1997*).

Methods

Study sites spanned an area roughly 28 km east-west and 14 km north-south downwind (east) of the primary pollution source in the Strathcona Industrial Area. Study sites were located in naturally forested areas both public and private. Two crews of two people each sampled a total 35 sites in mid-October 1999. Only mature trees with diameters >20 cm at breast height were sampled. Balsam Poplar was the preferred tree as its rough bark afforded abundant microsites for lichens. Aspen were also sampled. Prior to sampling, we learned to recognize a subset of the lichen flora. We focused on 15 taxa readily identifiable in the field.

At each site, we chose the four trees with the highest lichen cover. These trees had rough or fissured bark and were usually the largest and oldest trees present. Our data indicate average maximum cover rather than average cover. For each tree, we noted the tree species and diameter at breast height and determined the percent cover of each lichen species growing on the bark in the zone 0.5-1.5 m above the ground. Locations were recorded with a GPS unit. Lichen names follow Brodo et al. (2001).

For each site, we determined mean percent cover for each species and all combined species and the total number of species. Lichen cover and location data were analysed statistically. While air pollutants originate from the entire industrial area, and from Edmonton in general, we defined a single pollution source point to quantify distance from source. That point was defined as the junction of Baseline Road and 34th Street on the west side of Refinery Row. Distances from each site to the defined pollution source were determined in a geographic information system.

Results

Of the 15 taxa of corticolous lichens assessed, six tended to be common and dominant and nine uncommon and non-dominant (Tables 1, 2). Lichen species richness and cover increased with distance from the pollution source (Figure 2). Relationships with distance were strongest for species richness and for non-dominant species cover (Table 3). Both richness and cover appeared to rise exponentially with distance. Species richness and total cover increased gradually from west to east over the first 15-20 km of the pollution gradient, then increased more rapidly (Figure 3). Minimum richness and cover were found in the northwestern sites. Richness and cover continued to rise over the gradient indicating that air quality influenced the lichen community across the entire area. Some lichens near the refineries and in Sherwood Park showed abnormal coloration (e.g., pale colors, or pinkish hues) and poor thallus integrity (partly disintegrated thalli) indicative of stress.

Of the six dominant species, all but one species (*Phaeophyscia orbicularis*) increased in cover with dis-

TABLE 1. Corticolous lichen species observed on mature Balsam Poplar and Trembling Aspen bark in the study.*

Dominant Species
Melanelia albertana
Ochrolechia arborea
Phaeophyscia orbicularis
Physcia adscendens
Xanthoria fallax
Xanthoria hasseana
Non-dominant Species
Arthonia patellulata
Bryoria spp.
Evernia mesomorpha
Flavopunctelia flaventior
Hypogymnia physodes
Parmelia sulcata
Parmeliopsis ambigua
Physcia aipolia
Usnea spp.

* non-dominant species occurred at <5% cover at most sites

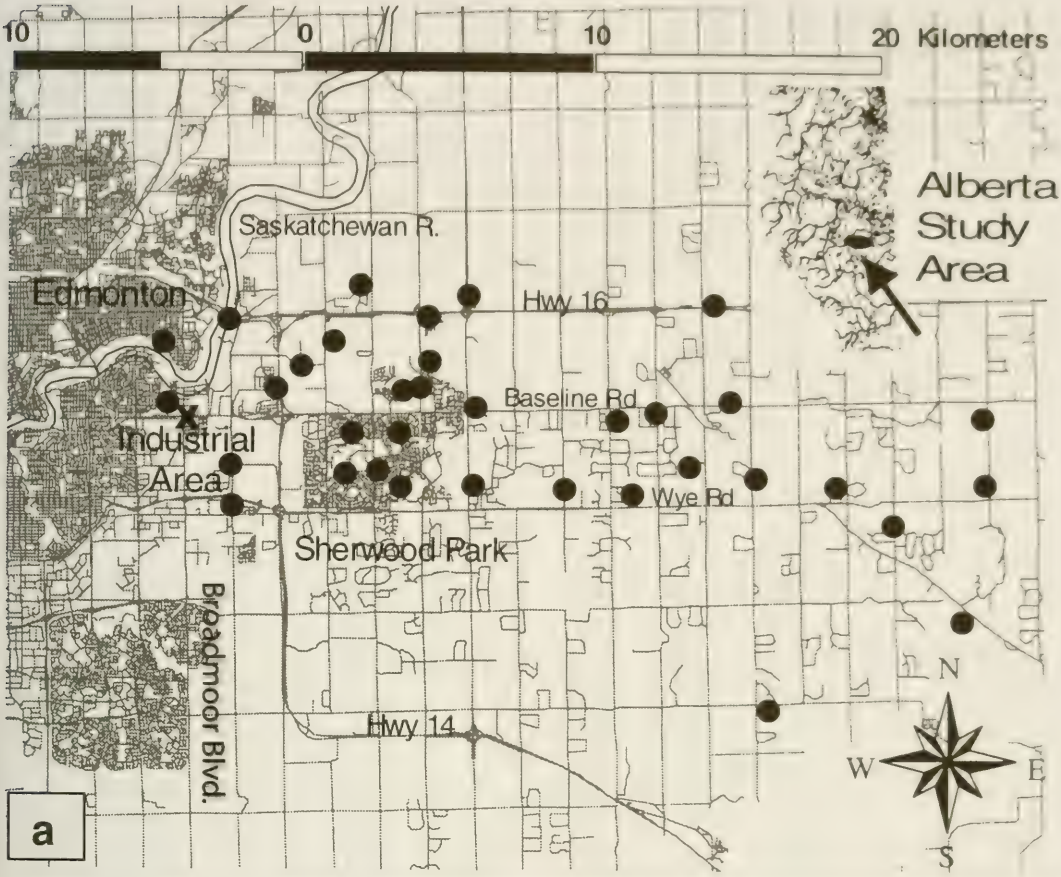

FIGURE 1. (a) Location of the 35 study sites. The area marked with an X, at the corner of Baseline Road and 34th Street (Edmonton), was the reference point for measurement of distances from the pollution sources. (b) Part of the Strathcona Industrial Area as seen from the corner of Baseline Road and Broadmoor Boulevard (west side of Sherwood Park, 9 June 2006).

TABLE 2. Cover (%) of six common, dominant lichen taxa, non-dominant species cover, total cover, species richness, distance from pollution source, and location (UTM, Alberta 10TM projection) for the 35 study sites.

Site	*Melanelia albertana*	*Ochrolechia arborea*	*Phaeophyscia orbicularis*	*Physcia adscendens*	*Xanthoria fallax*	*Xanthoria hasseana*	Non-dominant Spp. Cover %	Total Cover %	Species Richness (n)	Distance (km)	Easting (m)	Northing (m)
1	1.53	1.28	9.50	10.50	9.25	24.25	4.80	61.1	10	22.20	626596	5921921
2	1.53	1.75	6.25	27.50	15.50	20.78	3.57	76.9	12	27.64	634039	5929211
3	1.25	5.53	6.25	30.75	13.00	9.28	5.55	71.6	11	27.51	633318	5924801
4	9.50	6.25	5.50	18.75	9.25	6.25	5.13	60.6	10	27.43	633890	5931485
5	1.03	0.33	10.50	23.75	27.00	5.80	1.13	69.5	11	24.60	630881	5927914
6	1.03	1.05	17.00	9.50	8.50	6.25	1.01	44.3	9	22.63	628901	5929041
7	4.03	5.53	7.75	9.50	13.50	2.55	2.55	45.4	9	18.64	624657	5935012
8		0.08	18.75	20.25	8.25	0.03	0.30	47.7	6	19.84	626128	5929300
9		0.28	18.25	15.00	2.75	0.30	0.57	37.2	8	17.51	623892	5929777
10		0.55	12.50	20.50	14.25	0.03	0.32	48.2	8	18.84	625218	5931805
11	0.30	3.25	9.53	17.75	34.50	8.50	1.77	75.6	8	16.29	622666	5931547
12	0.28	3.53	4.78	17.00	11.25	1.55	1.51	39.9	8	15.67	621909	5928835
13		0.55	5.28	18.28	10.50	0.03	0.52	35.2	6	14.94	621306	5931245
14		0.10	12.00	11.28	18.00	9.28	2.08	52.7	9	13.34	619624	5928966
15		0.10	13.75	13.25	9.50	1.25	0.58	38.4	7	10.21	616349	5929036
16		0.05	9.00	18.75	15.00	8.78	0.07	51.7	7	10.07	616497	5931618
17		0.08	6.25	15.03	17.50	5.03	0.77	44.7	6	10.59	616212	5935306
18		0.08	15.25	0.28	12.00	19.50		47.1	5	9.07	614799	5934537
19			30.00	0.08	4.75	0.55	1.02	36.4	5	8.12	614509	5932293
20		0.03	16.25	0.08	9.00			25.4	4	8.56	614809	5932530
21	0.30	3.50	26.25	0.03	14.50	12.50	3.06	60.1	9	7.60	613904	5932179
22	0.03	0.30	23.75	1.55	16.25	1.28	0.90	44.1	11	7.39	613821	5930774
23		0.08	38.00	4.00	11.75	6.00	1.82	61.7	7	7.77	613885	5929036
24			10.00	18.78	1.03	0.03	0.08	29.9	6	3.28	608099	5928430
25		0.55	14.25	0.28	20.00	24.75	0.06	59.9	6	2.23	607989	5929730
26		0.05	14.50	1.55	15.00	0.53		31.6	5	3.36	609589	5932220
27		0.03	23.75	6.75	3.53	0.03	0.35	34.4	7	3.56	607909	5934560
28		0.05	9.50	0.55	1.05			11.2	5	2.58	605709	5933730
29		0.55	14.28	1.03	3.50	0.05	0.10	19.5	8	0.77	605895	5931731
30			10.50	0.08	16.25	3.78	0.05	30.7	5	5.87	612319	5930784
31		1.03	16.25	0.08	5.25	0.28	0.05	22.9	6	7.47	612501	5935549
32		3.03	26.25	6.30	4.78		0.75	41.1	5	5.77	611558	5933780
33		0.53	35.00	1.55	21.25	0.03	0.05	58.4	7	4.43	610409	5933009
34			31.25	3.00	26.52	0.75	0.28	61.8	5	6.86	613080	5929554
35		0.05	10.75	6.25	3.25	1.00	0.05	21.4	6	5.84	611981	5929452

tance from the pollution source (Figure 4). *Xanthoria fallax* and *Phaeophyscia orbicularis* were the most hardy lichens, present in virtually all sample sites. *Xanthoria hasseana* and *Ochrolechia arborea* increased appreciably in cover with distance from the refineries. *Physcia adscendens, Parmelia sulcata,* and *Melanelia albertana* were rare or absent near the pollution source and common in more distant areas. Similarly, *Flavopunctelia flaventior, Hypogymnia physodes, Usnea* sp., *Evernia mesomorpha,* and *Arthonia patellulata* were rare to absent near the refineries. Most species were sensitive to air quality to some degree.

Discussion

Lichens are good bioindicators of air quality in the region. There were clear trends of decreasing cover and richness with increasing proximity to Refinery Row.

TABLE 3. Spearman rank correlations of distance from pollution source with lichen species richness and cover ($n = 35$; all correlations were significant at $P<0.001$).

Correlations (r)	Distance
Species Richness	0.61
Total Cover	0.57
Dominant Species Cover	0.51
Non-dominant Species Cover	0.67

The pattern of decreasing lichen cover and species richness with increasing levels of air pollution is consistent with that documented in large Canadian cities such as Winnipeg, Manitoba (Stringer and Stringer 1974), and Hamilton, Ontario (McCarthy and Vaughan 2004*).

The results support those of Muir and McCune (1988) and van Dobben and ter Braak (1999) who found that

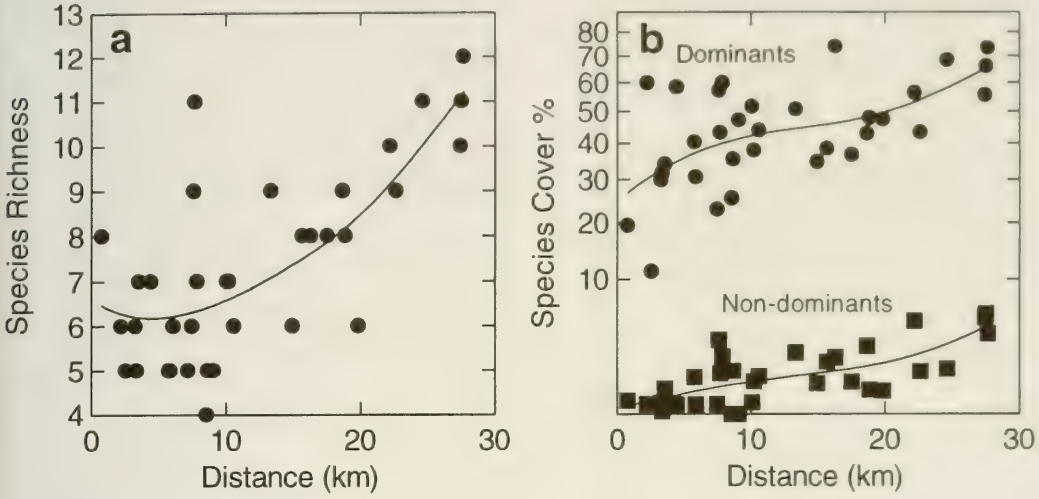

FIGURE 2. Lichen species richness (a) and total cover (b) in relation to distance from the pollution source. Line is a distance-weighted least squares regression, tension 1. The species cover y-axis is transformed, power 0.5.

air pollution reduces species richness, decreases total cover, alters species composition, and amplifies the presence of pollution-tolerant lichen species. *Phaeophyscia orbicularis* is a pollution-tolerant species; *Xanthoria polycarpa* (a close relative of *X. hasseana*) and *Ochrolechia* are moderately to significantly sensitive to SO_2 pollution (van Dobben and ter Braak 1999).

Several factors may have influenced the results. Lichen species richness differs among host tree species (Muir and McCune 1988). This influence was minimized by our choice of only Balsam Poplar and Trembling Aspen. Exposed and isolated tree patches may have had lower lichen cover and richness in part because isolated trees are more exposed to air pollutants than are forest trees (Smith 1981). Microsite differences may have affected our findings at some sites. The choice of four mature trees with maximum lichen cover at each site should have minimized differences due to unsuitable substrates (such as smooth bark on rapidly growing trees).

As the pollution originates from several sources, including refineries, local vehicle emissions, and urban combustion, distance from a single point source is a simplification. Most of the sites were near roadways and were likely affected by vehicle emissions. Differences in traffic load may have contributed to the variability in the lichen communities. Strathcona County official weekday traffic counts during 1997 and 1998 for arterial roads in the vicinity of Refinery Row ranged from 21 120 to 36 130 vehicles per day. In contrast, traffic counts near the easternmost rural sites ranged from 82 to 1252 vehicles per day (mean 326, $n = 15$).

A combination of industrial, vehicular, and urban emissions results in lower air quality in the Refinery Row area. Winds distribute and disperse the pollutants in complex ways evident in Figure 3. Air quality monitoring in Fort Saskatchewan, about 20 km north-northeast of Refinery Row, found that sulphur dioxide levels rose significantly (by 21%) when winds were from the south-southwest (Albert Health and Wellness 2003), a fact attributed to wind dispersal of pollutants from east Edmonton.

Air pollution is a serious health concern of millions of people worldwide and has been linked with higher rates of allergies and respiratory and cardiovascular diseases (Health Canada 2004*). Numerous epidemiological studies have demonstrated a link between ambient air pollution and adverse human health effects (Alberta Health and Wellness 2003). It can be difficult, however, to establish a causal relationship between exposure to a specific contaminant and a resultant health effect. Lack of a demonstrated causal link between a pollution source and human health does not mean that no link exists. Indeed, precautionary common sense should assume there may be a link until the required controlled studies are conducted. Sensitive bioindicators such as lichens can be used in the interim to inform public policy.

While air pollution effects upon the lichen communities are evident, levels of local monitored air quality parameters appear to be within Alberta government guidelines. This should perhaps not come as a surprise. Air quality guidelines are based in part upon science and in part upon what is feasible within the socioeconomic objectives of stakeholders (Long Fu, Alberta Environment, personal communication, 9 February 2006). Our results indicate that current air quality guidelines are inadequate for the protection of the lichen communities.

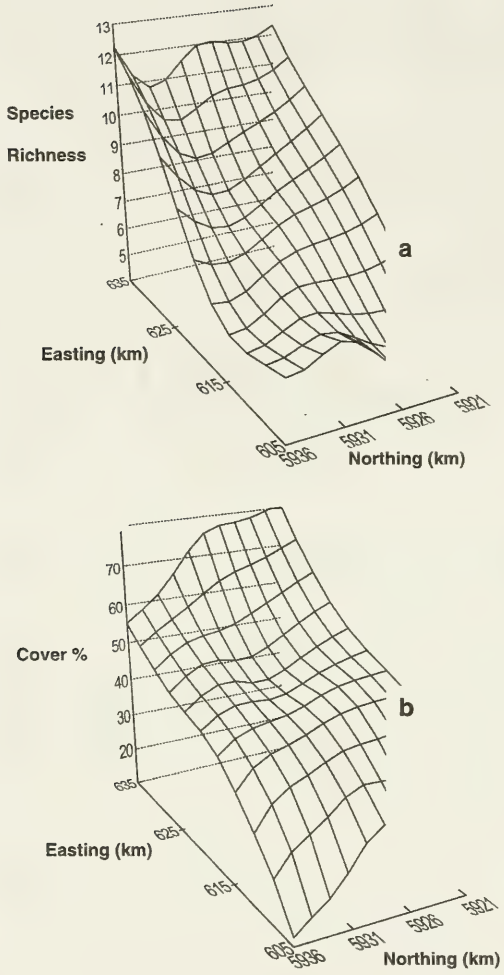

FIGURE 3. Lichen species richness (a) and total cover (b) in relation to location. The surface is a distance-weighted least squares regression, tension 1. The view is from the northwest towards the southeast. Coordinates are in Alberta provincial 10TM projection.

Despite widespread public concern, independent, journal-published studies of the relationships between air pollution and human health downwind of the Strathcona Industrial Area have not been conducted to date. Alberta Health (1996) conducted a small, short-term study of respiratory disease rates in Strathcona County and Fort Saskatchewan. They were unable to detect above normal rates of mortality and hospital admissions but observed above normal rates of physician visits for asthma. As a large human population is needed for robust statistical analyses, the statistical power of that study was limited. Ozone, acid aerosols, nitrogen oxides, volatile organic compounds, and particulates may be responsible for adverse health effects at current levels of exposure (Alberta Health 1996).

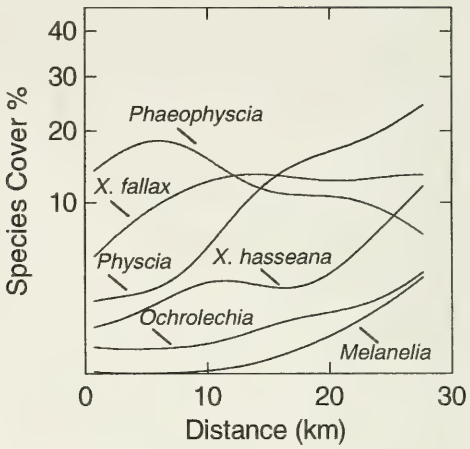

FIGURE 4. Lichen cover in relation to distance from the pollution source for the six dominant species. Line is a distance-weighted least squares regression, tension 1. The species cover y-axis is transformed, power 0.5.

As regards particulate matter, epidemiologic studies have been conducted that reveal a coherence and consistency of effects across a range of health outcomes and independent studies in different settings (Dockery and Pope 1994). Weighted mean increases in daily mortality of 1.0% (all causes of death), 1.4% (for cardiovascular deaths), and 3.4% (for respiratory deaths) for each 10 $\mu g/m^3$ increase in PM_{10} have been established (Dockery and Pope 1994). In Fort Saskatchewan, Alberta Health and Wellness (2003) observed a 95th percentile $PM_{2.5}$ outdoor concentration of 13.2 $\mu g/m^3$, corresponding to a PM_{10} concentration of ~ 23.3 $\mu g/m^3$ (when the 2005 ratio of 0.568 for $PM_{2.5}$ to PM_{10} in Alberta is applied). Such a concentration would be expected to cause an increased daily mortality of 2.3% for all causes of death, 3.3% for cardiovascular deaths, and 7.9% for respiratory deaths (Dockery and Pope 1994).

Political decisions on regional air quality issues have to date supported business as usual. As Strathcona County Councillor Alan Dunn sees it (personal communication, 16 February 2006), "we politicians spend too much time sticking our heads in the sand." Councillor Glen Lawrence (personal communication, 16 February 2006) supports an improved air quality monitoring program. Both Councillors agree that protection of air quality and human health must begin to play a central role in future decisions regarding development.

Rates of death from asthma in Canada increased sharply from 1970 through the early 1980s and subsequently remained high through the 1980s (Wilkins and Mao 1993). In Alberta from 1980 to 1988, hospital admissions for asthma increased 35% for children younger than 15 years and increased 48% for Albertans 15-34 years of age. Of all provinces in Canada, Alberta has the

highest death rate for asthma in people younger than 35 years of age (Wilkins and Mao 1993).

As sentinels of air quality, the lichens are telling us that all is not well in the air east of Edmonton, Alberta.

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The Hepatic Flora and Floristic Affinity of Hepatics Around Takakia Lake, Queen Charlotte Islands, British Columbia

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The known hepatic flora of the Takakia Lake area consists of 66 species, 2 subspecies, and 2 varieties, in 30 genera and 18 families. Thirty-seven taxa (51.8%) of the total 70 taxa present are boreal in distribution. Seven taxa (10.1%) are western North American and Amphi-Pacific elements. This clearly demonstrates that the greatest diversity of western North American hepatics occurs between 45°–55°N and between 120°–135°W which includes the lake (Hong 1988). Other distribution patterns include a taxon which is a North American boreal endemic and one which is a North American temperate endemic; two are cosmopolitan and disjunct montane; three are circumtemperate and circum-montane; six are temperate disjunct; eight are arctic and alpine; fourteen are boreal disjunct and twenty-three are circumboreal.

Key Words: Hepatics, Takakia Lake, Queen Charlotte Islands, British Columbia.

Takakia Lake is a high-elevation lake located on the northwestern part of Moresby Island, one of 150 islands that comprise the Queen Charlotte Islands (31°54'–54°13'N to 130°58'–133°06'W). The lake (52°55'N and 132°03'W) is situated at almost 650 m above sea level just at the tree line and measures 1.25 km in length and 0.75 km in width.

Before the discovery of the rare bryophyte *Takakia lepidozioides* (on soil, partly covering rocks) by Persson in 1958, the lake was unnamed (Figure 1).

The first report of *Takakia lepidozioides* was made by Hattori and Inoue (1958) using the specimen collected by Takaki in 1951 at 2400 m altitude on Mt. Shirouma, Japanese Alps, middle Japan. They described this species as a member of hepatics and placed it under the new order Takakiales, and the new family, Takakiaceae, based on sterile materials. Later the species was found in Borneo (Hattori 1963) and another species of *Takakia, T. ceratophylla,* was found in the Himalayas (Grolle and Long 2000).

For many years after the discovery of this species, many bryologists sought sporophytes of *Takakia.* Finally in 1990, Smith and Davidson (1990) reported sporophytes in the central Aleutian Islands and clarified the systematic position of *Takakia* as a moss with links to Andreaeopsida, previously suggested by Mizutani (1974) and Murray (1988).

The surrounding hills of Takakia Lake are mainly noncalcareous substrates which receive almost 5 000 mm annual precipitation; they are dominated by Sitka Spruce *(Picea sitchensis)* and Western Hemlock *(Tsuga heterophylla).* There are many suitable moist areas that favor the growth of hepatics, especially alpine meadows that have developed on north-exposed slopes of the lowest part of the alpine region at the eastern end of the lake.

The most common herbs are *Senecio triangularis, Mitella pentandra, Habenaria saccata, Vahlodea atropurpurea, Eriophorum angustifolium, Erigeron peregrinus, Veratrum eschscholtzii, Saxifraga punctata, Cardamine umbellata, Epilobium delicatum, Tiarella trifoliata, Dodecatheon jeffreyi,* and *Heracleum lanatum* (Calder and Taylor 1968). Hepatics are abundant along a small stream running through the meadows.

In 1969, V. J. Krajina and his colleagues of Department of Botany, University of British Columbia, proposed that the provincial government preserve the lake as an ecological reserve, citing the need to protect representative ecosystems, rare genetic resources, and outstanding biological phenomena in a remote alpine setting. The proposal was considered by the government; however, it was never approved.

The lake flows into Moresby Lake, which feeds a turbine and supplies electric power to Moresby Island and the southern part of Graham Island. In 1997, Queen Charlotte Power Corporation from Vancouver, British Columbia, proposed the drilling of holes into Takakia Lake to supply water for more electric power, thus reducing the water level of the lake. Any such drawdown of the lake would destroy the sensitive habitat of most of its endangered or threatened species of plants, especially hepatics, mosses and lichens.

It is necessary to preserve the lake's constant water level to protect this unique representative ecosystem of an alpine lake, rare genetic resources, and outstanding biological phenomena in a remote, clear, and unpolluted lake. Hepatics especially are so sensitive to humidity that if water were drained from the lake during their vigorous growing season (summer), they would die or would disappear. Such phenomena have been clearly demonstrated by the cutting of old-growth forests around various lakes or along the stream banks resulting in reduced water availability.

Along the shore line of Takakia Lake, there are numerous rare species vulnerable to water level change,

FIGURE 1. Takakia Lake in Queen Charlotte Islands (after Provisional Resource Description & Analysis. South Moresby/ Gwaii Haanas National Park Reserve 1990)

including *Takakia lepidozioides* (under Musci), and the following hepatics: *Anastrophyllum assimile, Anthelia julacea, Diplophyllum imbricatum, D. plicatum, Gymnomitrion pacificum, Herbertus sakuraii, Hygrobiella laxifolia, Kurzia sylvatica, Lepidozia filamentosa, Marsupella alpina, M. boeckii, Pleurocladula albescens,* and *Pleurozia purpurea.*

In order to secure luxurious growth and maintenance of its biodiversity of bryophytes through ample moisture, a constant water level should be maintained in Takakia Lake.

The author made collecting trips during the summers of 1999, 2000 and 2001. Voucher specimens have been deposited at the herbarium of the University of Great Falls, Montana (GFC), with available duplicates in the herbarium of University of Cincinnati (CINC). This report is based on author's collections, specimens borrowed from Chicago Natural History Museum (F), Swedish Museum of Natural History (S), and University of British Columbia (UBC) and literature reports from the following: Persson (1958); Miller (1968); Schofield (1968); Hong (1992, 1993). In general, nomenclature follows Stotler and Crandall-Stotler (1977) and Grolle and Long (2000). Only one representative specimen of each taxon is cited. Genera and species are listed alphabetically.

Annotated Checklist of the Liverworts of Takakia Lake Area

Anastrophyllum (Spruce) Steph.
- *assimile* (Mitt.) Steph. – wet cliff crevices. (Persson 1958)

Anthelia (Dumort.) Dumort.
- *julacea* (L.) Dumort. – wet rocks. 00-397.
- *juratzkana* (Limpr.) Trevis – humus on rocks. 99-179.

Barbilophozia Loeske
- *floerkei* (F. Weber & D. Mohr) Loeske – shaded rocks. 00-400.
- *hatcheri* (A. Evans) Loeske – partially shaded ledge. Persson s.n.(S).
- *kunzeana* (Huebener) Müll. Frib. – moist ledge. Schofield 25158 (F).
- *lycopodioides* (Wallr.) Loeske – shaded, moist ledge. Persson s.n. (S).

Bazzania Gray
- *pearsonii* Steph. – rocks and soil. Schofield 25158 (UBC). (Schofield 1968).
- *tricrenata* (Wahlenb.) Lindb. – bark, decayed wood, and soil. 99-256.

Blepharostoma (Dumort.) Dumort.
- *trichophyllum* (L.) Dumort. subspecies *trichophyllum* – shaded, moist soil, rocks and decayed wood. 99–180

Calypogeia Raddi
- *azurea* Stotler & Crotz. – shaded, decayed wood and moist soil. (Persson 1958).
- *integristipula* Steph. – shaded, decayed wood and moist soil. 01-206.
- *neesiana (C.* Massal. & Carestia) Müll. Frib. – shaded, decayed wood and moist soil. 99-208.

Cephalozia (Dumort.) Dumort.
- *ambigua C.* Massal. – shaded, decayed wood and moist soil. 015-216.
- *bicuspidata* (L.) Dumort. – shaded, decayed wood 99-195.
- *leucantha* Spruce – shaded, decayed wood. 01-230.
- *lunulifolia* (Dumort.) Dumort. – shaded decayed wood. wet rocks and stream banks. 99-180.
- *macounii* (Austin) Austin – decayed wood and moist soil. 99-182.

Diplophyllum (Dumort.) Dumort.
- *albicans* (L.) Dumort. – shaded, decayed wood, soil and rocks. 99-170.
- *imbricatum (M. A.* Howe) Müll. Frib. – rocks. (Persson 1958; Hong 1993).
- *plicatum* Lindb. – shaded, decayed wood and thin soil over wet rocks. (Persson 1958).
- *taxifolium* (Wahlenb.) Dumort. – shaded ledge. 99-253.

Eremontus Lidnb. & Kaalaas in Pearsson
- *myriocarpus* (Carrington) Pearson – wet rocks. Godfrey and Schofield (1979).

Frullania Raddi
- *nisquallensis* Sullivant – branches and bark, decayed wood and humus on rocks. 99-175.

Gymnomitrion Corda
- *concinnatum* (Lightf) Corda – rocks. Schofield 24279 (UBC).
- *obtusum* Lindb. – acid rocks. 99-253.
- *pacificum* Grolle – wet rocks. (Persson 1958; Schofield 1968).

Herbertus Gray
- *aduncus* (Dicks.) Gray – bark and soil. Schofield 24788 (UBC).
- *sakuraii* (Warnst.) S. Hatt. – bark and soil. 99-194.

Hygrobiella Spruce
- *laxifolia* (Hook.) Spruce – peat bog. Schofield 25058 (UBC). (Schofield 1968).

Jungermannia L.
- *hyalina* Lyell – wet soil or soil covered rocks. Persson s.n. (S). (Váña & Hong 1999).
- *obovata* Nees – shaded, decayed wood and wet soil near stream. 99-245.
- *pumila* With. – wet rocks near stream. 99-266a.

Kurzia G. Martens
- *sylvatica* (A. Evans) Grolle – decayed wood and soil. 99-165.

Lepidozia (Dumort.) Dumort.
- *filamentosa* (Lehm. & Lindenb.) Lindenb. – shaded, decayed wood (Persson1958)
- *reptans* (L.) Dumort. – shaded, decayed wood. 99-255.

Lophozia (Dumort.) Dumort.
- *incisa* (Schrad.) Dumort. – shaded, moist decayed wood. 99-285.
- *longiflora* (Nees) Schiffn. [= *ventricosa* var. *longiflora* (Nees) Macoun;
- = *guttulata* (Lindb. & Arm.) Schiffn.] – decayed wood and soil. 99-255.
- *opacifolia* Culm. ex Meyl. – wet soil. 00-402.
- *sudetica* (Nees) Grolle – wet outcrop. 00-394.
- *ventricosa* (Dicks.) Dumort. – decayed wood and soil. 99-218.
- *wenzelii* (Nees) Steph. – humus on decayed wood. 00-475.

Marsupella Dumort.
- *alpina* (Gottsehe ex Husn.) Bernet. – rocks. 99-253.
- *boeckii* (Austin) Kaal. – rocks. 99-179 (Hong 1992).
- *emarginata* (Ehrh.) Dumort. – moist soil near stream and wet rocks. 99-218.
- var. *aquatica* (Lindenb.) Dumort. – submerged. 99-168. This variety is very abundant, covering wet rocks in the streamlets of the entire meadow, disdistinguished from var. *emarginata* by its rigid texture, black color, shallow-

ly bilobed leaves with narrow sinus and bulging trigones. Many rhizoids are distinctly purplish.

Moerckia Gottsche
blyttii (Moerch) Brockm. – wet soil near stream. 00-479.

Mylia Gray
taylorii (Hook.) Gray – shaded, decayed wood and moist soil. 99-191.

Nardia Gray
compressa (Hook.) Gray – seep margins of stream. 99-198.
geoscyphus (De Not.) Lindb. – moist soil and wet rocks near stream. 00-411.
japonica Steph. – soil. Schofield 25028 (UBC).
scalaris Gray – moist soil and wet rocks near stream. 99-266b.

Pellia Raddi
endiviifolia (Dicks.) Dumort. – wet rocks and soil near stream. 99-266a.
epiphylla (L.) Corda – moist soil near stream. 01-190.
neesiana (Gottsche) Limpr. – moist soil near stream. 99-200.

Plagiochila (Dumort.) Dumort.
porelloides (Torrey ex Nees) Lindenb. – moist soil and decayed wood. 99-214.

Pleurocladula Grolle
albescens (Hook.) Grolle – moist soil near stream. 01-196. (Persson 1958).

Pleurozia Dumort.
purpurea Lindb. – peat bog. Schofield 25058 (UBC). (Schofield 1968)

Ptilidium Nees
californicum (Austin) – bark and decayed wood. 99-175.

Radula Dumort.
auriculata Steph. – shaded, wet cliffs and bark. Schofield 25060 (UBC). Schofield (1968).
obtusiloba subsp. *polyclada* (A. Evans) S. Hatt. – wet rocks, soil and humus on decayed wood. 00-464.

Riccardia Gray
latifrons (Lindb.) Lindb. – shaded, decayed wood and peat. 00-433.
palmata (Hedw.) Carruth. – shaded, decayed wood. 99-255.

Scapania (Dumort.) Dumort.
americana Müll. Frib. – wet soil near stream. 01-68.
bolanderi Austin – bark, decayed wood and soil. 99-170.
paludosa (Müll. Frib.) Müll. Frib. – wet rocks near stream. 01-104.
undulata (L.) Dumort. – shaded, decayed wood and wet soil near stream and waterfalls. 99-256. Many collections show distinct reddish-blackish color due to light exposure and are superficially similar to S. *uliginosa*.
var. *oakesii* (Austin) Müll. Frib. – wet rocks near stream. 01 -104.

Tritomaria Schiffn. ex Loeske
quinquedentata (Huds.) H. Buch – shaded rocks. 99-214.

Geographical Relationships

The known hepatic flora of Takakia Lake area consists of 70 taxa; twelve different distributional elements (Table 1) are presented. The world distribution categories follow those given in Belland et al. (1992) and Hong (1999).

1. *Cosmopolitan element*s (2 taxa 3.0%). The taxa of this group are not restricted to major vegetational biomes – arctic, boreal, temperate and tropical zones.

TABLE 1. The floristic affinities of the Hepaticae of Takakia Lake.

Elements	Number of hepatics	(%)
1. Cosmopolitan	2	(3.0)
2. Circumboreal	23	(32.2)
3. Boreal disjunct	14	(19.6)
4. North American boreal endemic	1	(1.5)
5. Circumtemperate	3	(4.6)
6. Temperate disjunct	6	(8.5)
7. North American temperate endemic	1	(1.5)
8. Circum-montane	3	(4.6)
9. Disjunct-montane	2	(3.0)
10. Arctic and alpine	8	(11.4)
11. Amphi-Pacific	5	(7.1)
12. Western North American endemic	2	(3.0)
Total	70	(100.0)

Jungermannia hyalina and *Riccardia palmata* belong to this element.

2. *Circumboreal elements* (23 taxa, 32.2%). Almost one-half of the hepatics around the lake belong to the boreal elements (51.8%), and are predominantly (32.2%) circumboreal. The latter are widespread throughout the Northern Hemisphere within the boreal biomes. Representative taxa are *Anastrophyllum assimile, Barbilophozia hatcheri*), *B. lycopodioides, Blepharostoma trichophyllum, Calypogeia integristipula, C. neesiana, Cephalozia lunulifolia, C. macounii, Diplophyllum taxifolium, Gymnomitrion concinnatum, Jungermannia pumila, Lepidozia reptans, Lophozia incisa, L. longiflora, L. ventricosa, L. wenzelii, Marsupella emarginata* and var. *aquatica, Nardia compressa, N. geoscyphus, Plagioichila porelloides, Riccardia latifrons* and *Tritomaria quinquedentata.*

3. *Boreal elements* (14 taxa, 19.6%). The species of this group have major gaps in their world distribution. Representative taxa are *Barbilophozia voerkei, Bazzania tricrenata, Cephalozia leucantha, Diplophyllum albicans, Gymnomitrion obtusum, Hygrobiella laxifolia, Moreckia blyttii, Mylia taylori, Nardia scalaris, Pellia endiviifolia, P. epiphylla, Pleurozia purpurea, Scapania undulate* and var. *oakesii.*

4. *North American boreal endemic elements* (a taxon, 1.5%). Only one taxon, *Diplophyllum imbricatum*, belongs to this element.

5. *Cicumboreal element* (3 taxa, 4.6 %). The taxa of this group; are widely distributed in the temperate forests of the Northern Hemisphere including Europe. Asia and eastern and western North America. Examples are *Calypogeia azurea, Cephalozia bicuspidata,* and *Pellia neesiana.*

6. *Temperate disjunct elements* (6 taxa, 8.5%). The taxa of this group occur in the same region as the above group; however, they are absent from one or two of the above regions. Examples are *Gymnomitrion pacificum, Herbertus aduncus, Kurzia sylvatica, Lepidozia fila-*

mentosa, Plagiochila semidecurrens, and *Radula auriculata.*

7. *North American temperate endemic elements* (a taxon, 1.5%). The taxon is restricted to temperate forest of North America. *Scapania americana* belongs to this group.

8. *Circum-montane elements* (3 taxa, 4.6%). The taxa in this element are *Bazzania pearsonii, Marsupella alpina* and *M. boeckzii.*

9. *Disjunct-montane elements* (2 taxa, 3.0 %). Only *Jungermannia obovata* and *Scapania paludosa* belong to this element.

10. *Arctic-alpine elements* (8 taxa, 11.4%). The taxa restricted to arctic and alpine areas. Examples are *Anthelia julacea, A. juratzkana, Barbilophozia kunzeana, Cephalozia ambigua, Eremontus myriocarpus, Lophozia opacifolia, L. sudetica* and *Pleurocladula albescens.*

11. *Amphi-Pacific elements* (5 taxa, 7.1%). The taxa of this group occur in the Northern Pacific coast of Asia (from Kamchatka to the northern tip of the Philippines, including southeastern area of China, Formosa, the southern part of Korea and Japan) and North America (from Alaska to California, including the southwestern part of Yukon, Idaho and western part of Montana). Examples are *Diplophyllum plicatum, Herbertus sakuraii, Nardia japonica, Ptilidium californicum,* and *Scapania bolanderi* (see Hong 1988).

12. *Western North American endemic elements* (2 taxa, 3.0%). The taxa of this group are restricted to the western part of North America, including *Frullania nisqualensis* and *Radual obtusiloba* subsp. *polyclada.*

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Comparison of Scales, Pectoral Fin Rays and Opercles for Age Estimation of Ontario Redhorse, *Moxostoma*, Species

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Opercle based age estimates of four redhorse species (*Moxostoma anisurum*, *M. carinatum*, *M. macrolepidotum* and *M. valenciennesi*) were compared with those from two structures that can be obtained non-lethally (scales and pectoral fin rays). For all species, age estimates from scales were significantly lower than those obtained from fin rays and opercles. After ages 4 to 5, age estimates from scales were consistently lower than those from the opercle. Overall differences between age estimates from fin rays and opercles were only detected for *M. anisurum*. For all species, age estimates from fin rays were consistently lower than opercles after ages 12 to 15. Closer agreement among different structures was identified for populations of *M. macrolepidotum* comprised of younger individuals. Maximum ages reported for Ontario populations were higher than those previously reported across the species' ranges, reflecting either geographic differences in growth and longevity, or the historical use of scales for age estimation.

Key Words: redhorse, *Moxostoma*, age interpretation, calcified structures, Ontario.

Redhorses (*Moxostoma* spp.) are relatively large, laterally compressed and superficially similar suckers (Scott and Crossman 1979). In southern Ontario rivers, redhorse comprise a large proportion of fish biomass (Cooke and Bunt 1999). However, like many non-sport fish species in Canada, little is known about redhorse life history (Cooke et al. 2005). Of the six redhorse species in Ontario, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Black Redhorse (*M. duquesnei*) as nationally threatened and the River Redhorse (*M. carinatum*) as a species of special concern (COSEWIC 2005*). These two species and the Greater Redhorse (*M. valenciennesi*) are also imperiled in several neighbouring Great Lakes states (NatureServe 2005*). Recovery efforts for fish species at risk in Canada are limited by a lack of knowledge regarding their ecology, population size and factors that affect distribution and abundance.

Population age information is necessary for determining growth and mortality rates, age at maturity, and understanding the effects of environmental changes. Most redhorse age interpretations have used scales (Meyer 1962; Carlander 1969; Bowman 1970; Hackney et al. 1970; Curry and Spacie 1984; McAllister et al. 1985; Sule and Skelly 1985; Kwak and Skelly 1992; Cooke and Bunt 1999). Compared to fin rays or the opercle, scales typically underestimate age of older catostomids (Chalanchuk 1984). In older fish, annuli may be crowded at the distal edge due to minimal or non-existent scale growth and/or scale edges may be reabsorbed and annuli lost. Annulus formation in Shorthead Redhorse (*M. macrolepidotum*) pectoral fin rays was validated by Harbicht (1990). However, while less likely to underestimate age than scales, fin ray based age interpretations for older redhorse can be less accurate than those from either the opercle or otolith (Huston 1999). Re-absorption of the central part of the fin rays can obscure the first annulus and crowding of annuli in distal portions may occur in older fish, leading to potential errors in age determination (Beamish and Chilton 1977; Quinn and Ross 1982). If the fin ray is cut too far from the body, the core may not be seen or the annulus may be missing (Howland et al. 2004). The primary disadvantage of age estimation based on the opercle or otolith is that the fish must be killed in order to obtain the structure. As well, burnt or cracked otoliths have poor archival properties compared to fin rays (Howland et al. 2004).

Population monitoring of fish species at risk may require non-lethal sampling methods. Method comparisons assist in evaluating which is most efficient, reliable and appropriate for a given population study (Beckman 2002). If similar ages are observed using different structures then the most accessible and easily interpreted should be used (Howland et al. 2004). The objective of this study was to compare opercle based age estimates of four redhorse species (Greater Redhorse, River Redhorse, Shorthead Redhorse and Silver Redhorse (*M. anisurum*)) with age estimates from two structures that can be obtained non-lethally (scales and pectoral fin rays). The opercle was used, instead of the otolith, because it requires less preparation time and provides age estimates that are in close agreement with the otolith (Howlett 1999; Huston 1999).

Methods and Materials

Between 2000 and 2004, redhorse were collected from multiple sites across three southern Ontario drainages: Bay of Quinte (44°6'N, 77°28'W), Grand River (43°6'N, 80°19'W), and Ottawa River (45°39'N,

TABLE 1. Number and size range (total length: TL) of redhorse sampled from the Ottawa River, Bay of Quinte and Grand River drainages in Ontario.

	Greater Redhorse		River Redhorse		Shorthead Redhorse		Silver Redhorse	
Drainage	Number	TL (cm)	Number	TL (cm)	Number	TL (cm)	Number	TL (cm)
Ottawa River	7	51.0–63.5	8	40.0–65.0	51	18.8–55.4	87	15.2–66.0
Bay of Quinte	17	39.2–59.8	18	47.3–73.2	26	38.4–55.6	67	33.8–63.3
Grand River	11	40.3–63.9	1	64.7	37	24.5–53.7	–	–
All	35	39.2–63.9	27	40.0–73.2	114	18.8–55.6	154	15.2–66.0

76°42'W) (Table 1). Sampling occurred either as part of targeted redhorse inventories or Ontario Ministry of Natural Resources (OMNR) fish community sampling programs. Redhorse were collected using gill-nets, hoop-nets or a boat electro-fishing unit. Scales were collected below the dorsal fin above the lateral line on the left side of the fish. The most anterior pectoral fin ray on the left side of the body was removed using wire cutters as close to the body as possible. The opercle, a thin flat bone that covers the gills, was also removed. All structures were placed in a scale envelope to dry.

Two to five scales were pressed onto acetate slides using a roller press and read on a microfiche projector. Pectoral fin rays were embedded in epoxy, sectioned with a low-speed Isomet saw (section width 600 μm) mounted on a slide and polished with 320 and 600 grit wet sandpaper. Opercles were placed in hot water for several minutes to facilitate tissue removal with a toothbrush and then air dried. Fin ray sections and opercles were interpreted using a dissecting microscope and transmitted light. Identification of scale, fin ray and opercle annuli was based on illustrations provided by Chalanchuk (1984), Harbicht (1990) and Marcogliese (1996). Age assignment was based on annulus counts and edge condition data (Casselman 1987). Annuli number and edge condition were assigned without knowledge of fish size or date of collection. Before structures were interpreted, a subsample (~10) of each structure was interpreted with a second experienced reader to improve confidence in annuli identification.

For each species, statistical differences between age estimates based on scale, pectoral fin ray and opercle were tested using Friedman's test and a non-parametric multiple comparisons procedure for ranked data (Zar 1999). Age bias plots (Campana et al. 1995) were constructed to assess age bias from scales and pectoral fin rays compared to opercle bones. Repeatability of age estimates was evaluated by re-interpreting a subset (30 to 50) of each structure within one year of first interpretation. Percent agreement (absolute and ± 1 year) of first and second interpretations was calculated.

Results

For all species, age estimates from scales, fin rays and opercles were not equal (Friedman's test statistic: 31.8 to 134.7; $P < 0.001$). Age estimates from scales were significantly lower than those obtained from either fin rays or opercles (Table 2). After ages 4 to 5, age estimates from scales were consistently lower than those

TABLE 2. Comparisons of redhorse age estimates and repeatability for each aging structure. Statistically different age estimates are indicated by different superscripts (A, B or C).

Structure	Greater Redhorse	River Redhorse	Shorthead Redhorse	Silver Redhorse
Mean age[1]				
Scale	5.9 (2-9)^{A}	7.4 (4-13)^{A}	5.1 (1-10)^{A}	7 (1-11)^{A}
Fin ray	8.7 (4-15)^{B}	11.3 (7-19)^{B}	8.5 (2-18)^{B}	11.4 (2-23)^{B}
Opercle	9.4 (4-20)^{B}	11.6 (6-27)^{B}	8.7 (1-20)^{B}	12.9 (1-27)^{C}
Mean pairwise difference in age estimates[1]				
Scale vs. Fin ray	3.0 (0-8)	3.9 (1-11)	3.7 (0-10)	4.4 (0-15)
Scale vs. Opercle	3.5 (0-11)	4.3 (0-16)	3.9 (0-12)	6.3 (0-22)
Fin ray vs. Opercle	1.4 (0-6)	2.3 (0-9)	1.5 (0-9)	2.4 (0-11)
Percent agreement between structures[2]				
Scale vs. Fin ray	3.4 (13.8)	0 (8.7)	4.3 (17.0)	1.9 (18.1)
Scale vs. Opercle	3.2 (22.6)	8.3 (37.5)	9.4 (27.1)	5.7 (19.0)
Fin ray vs. Opercle	27.3 (63.6)	29.6 (48.1)	30.6 (63.1)	28.7 (54.3)
Percent agreement between first and second readings[2]				
Scale	74 (100)	72 (89)	60 (74)	48 (68)
Fin ray	85 (100)	80 (94)	87 (98)	64 (93)
Opercle bone	64 (91)	96 (100)	54 (88)	70 (94)

[1]Age range in parentheses. [2]Percent agreement ± one year in parentheses.

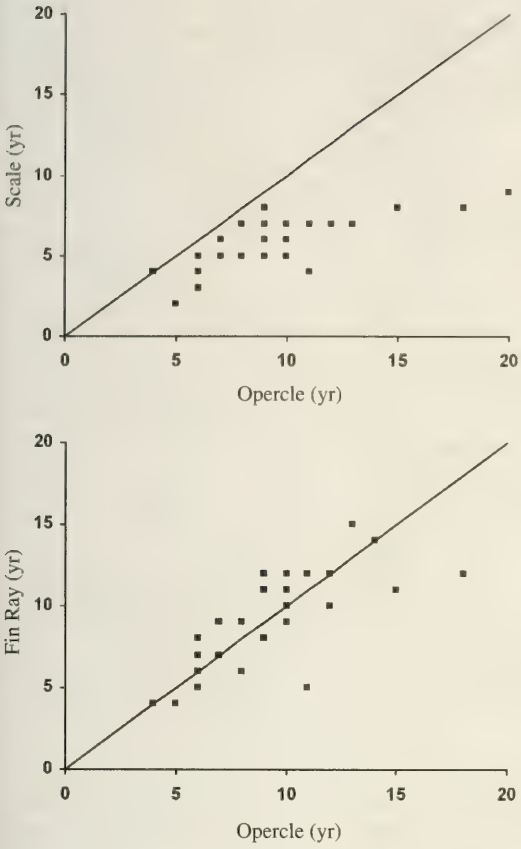


FIGURE 1. Comparison of Greater Redhorse opercle-based age estimates with those from scales (top) and pectoral fin rays (bottom). Opercle vs. scale CV (mean ± SE): 20.8 ± 2.3. Opercle vs. pectoral fin ray CV: 10.6 ± 3.6.

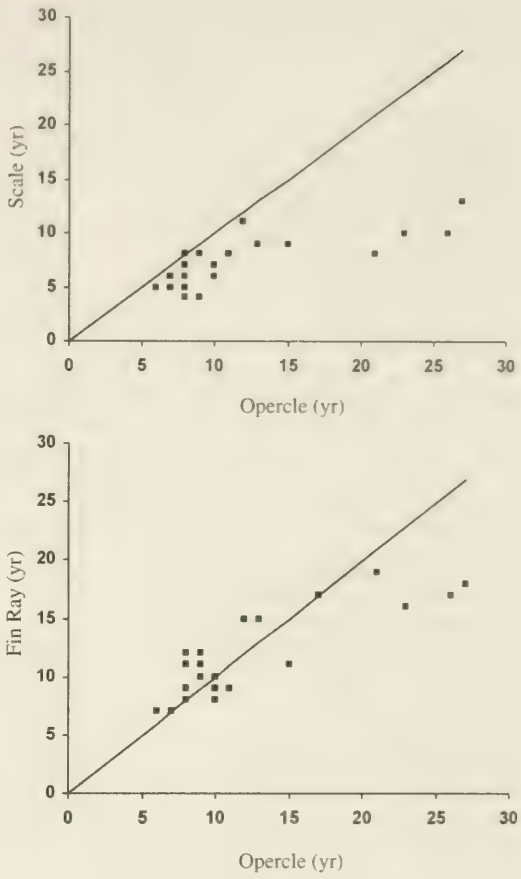


FIGURE 2. Comparison of River Redhorse opercle-based age estimates with those from scales (top) and pectoral fin rays (bottom). Opercle vs. scale CV (mean ± SE): 28.6 ± 5.8. Opercle vs. pectoral fin ray CV: 8.4 ± 1.4.

from the opercle (Figures 1 to 4). Mean pairwise differences between scale-based age estimates and those from fin rays and opercles were at least double that between fin rays and opercles (Table 2). Regenerated scales were common.

Agreement between age estimates from fin rays and opercles was greater than that between scales and the other two structures (Table 2). For all species except Silver Redhorse, there were no significant differences between age estimates from fin rays and opercles. However, the maximum difference between age estimates from these two structures was as large as 6 to 11 years. Fin ray based maximum age estimates were also 2 to 4 years less than those from opercles (Table 2). More frequent underestimation of age using fin rays began between ages 12 and 15 (Figures 1-4). For all species except Greater Redhorse, agreement between first and second interpretations of each structure was greater for pectoral fin rays and opercles than for scales (Table 2).

For Shorthead Redhorse and Silver Redhorse, sample numbers permitted an evaluation of whether differences in age estimates among structures were consistent across drainages. For Shorthead Redhorse, there was a greater level of agreement among Grand River structures (mean pairwise differences: 1.2 to 2.9 years) than among those from the Bay of Quinte (mean pairwise differences: 1.6 to 4.4 years) and Ottawa River (mean pairwise differences: 2.0 to 4.8 years) populations. The pattern reflects among drainage differences in the age of redhorse sampled, as Grand River Shorthead Redhorse were younger (mean age: 7.3) than those from Bay of Quinte (mean age: 9.2) and Ottawa River (mean age: 10.7). The level of agreement among structures from Silver Redhorse was equivalent for the similarly aged Bay of Quinte (mean pairwise differences: 2.4 to 5.9 years) and Ottawa River (mean pairwise differences: 2.4 to 6.5 years) Silver Redhorse populations. The mean age of both populations was 13 years.

TABLE 3. Comparison of maximum size (TL in cm) and maximum age for redhorse reported in past studies. For maximum age, superscript indicates structure used in the study: S:scale; F:fin ray: and O:opercle.

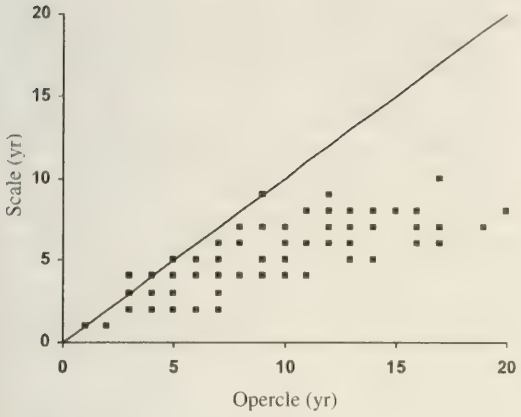
Location	Maximum Size	Maximum Age	Reference
Greater Redhorse			
Grand River, Ontario	–	13^{S}	Cooke and Bunt (1999)
Grand River, Ontario	66.7	20^{O}	This study
Trent River, Ontario	68.8	15^{O}	This study
Ottawa River and tributaries, Ontario	63.5	10^{O}	This study
St. Lawrence River and tributaries, Quebec	59.4	15^{F}	Mongeau et al. (1992)
River Redhorse			
Cahaba River, Alabama	59.7	5^{S}	Tatum and Hackney (1970)
Meramec River, Missouri	59.7	12^{S}	Carlander (1969)
James River, Missouri	67.5[1]	15^{O}	Huston (1999)
Grand River, Ontario	77.8	23^{F}	This study
Trent River, Ontario	78.7	27^{O}	This study
Ottawa River and tributaries, Ontario	46.1[2]	14^{S}	McAllister et al. (1985)
Ottawa River and tributaries, Ontario	79.8	28^{O}	Campbell 2001
St. Lawrence River and tributaries, Quebec	66.9	20^{F}	Mongeau et al. (1992)
Shorthead Redhorse			
Des Moines River, Iowa	65.5[3]	8^{S}	Meyer (1962)
Kankakee River, Illinois	40.4	8^{S}	Sule and Skelly (1985)
Grand River, Ontario	53.7	17^{O}	This study
Trent River, Ontario	61.5	19^{O}	This study
Ottawa River and tributaries, Ontario	55.4	20^{O}	This study
St. Lawrence River and tributaries, Quebec	41.6	11^{F}	Mongeau et al. (1992)
Saskatchewan River, Saskatchewan	41.9[4]	12^{S}	Scott and Crossman (1979)
Dauphin Lake, Saskatchewan	50.5	18^{F}	Harbicht (1990)
Silver Redhorse			
Cahaba River, Alabama	62.0	10^{S}	Hackney et al. (1970)
Des Moines River, Iowa	51.8	9^{S}	Meyer (1962)
Trent River, Ontario	67.5	23^{O}	This study
Ottawa River and tributaries, Ontario	66.0	25^{O}	This study
St. Lawrence River and tributaries, Quebec	57.8	21^{F}	Mongeau et al. (1992)

[1]Based on age-length figure; [2]Standard length; [3]Jenkins and Burkhead (1993) suggest specimen was either Greater Redhorse or River Redhorse; and, [4]Fork length.

Discussion

This study indicates that pectoral fin rays are a more precise and accurate non-lethal age interpretation structure for redhorse than scales. However, underestimation of age can occur for fish older than 12 to 15 years. Observed overestimation of age at younger ages indicates the presence of false annuli or checks. Errors in the age interpretation of long-lived fishes can lead to substantial errors in estimates of growth, reproductive lifespan, age at maturity and survivorship. For northern redhorse populations where there is a larger representation of old individuals, pectoral fin ray based ages could overestimate growth and mortality rates and underestimate age at maturity. Determination of whether re-absorption of initial annuli occurs (Penha et al. 2004) would assist in further assessments of error associated with pectoral fin rays. If re-absorption is occurring in redhorse, age interpretations of older individuals could be improved by estimating the location of the first and second annuli using their average diameter calculated from juvenile fish, or those with clearly visible annuli (McFarlene and King 2001).

Maximum ages for Greater Redhorse (20 years), Shorthead Redhorse (20 years) and Silver Redhorse (27 years) are the oldest reported for these species (Table 3). The maximum for River Redhorse (27 years) was similar to that reported by Campbell (2001) for the Mississippi River, Ontario (28 years). The substantially higher maximum ages for Ontario populations could be the result of either the geographic differences among the populations compared or that most past studies have used scales to estimate age. Many of the redhorse species found in Ontario are near the northern limit of their range (Scott and Crossman 1979). For freshwater species with wide geographic distributions, northern populations tend to exhibit lower growth rates, later maturity and greater longevity than southern populations (Colby and Nepszy 1981; Mills 1988). For example, Huston (1999) reported the maximum age (interpreted from opercles) of more southerly River Redhorse populations in Missouri to be 15 years. Alternatively, the low maximum age of 5 years reported by Tatum and Hackney (1970) for river redhorse in the Cahaba River, Alabama, was likely an underestimation of age as a result of using scales (Jenkins and Burkhead 1993). For similarly sized (~60 cm TL) River Redhorse, scale-based age estimates from Huston (1999), Campbell (2001) and this study were up to 15 years less than



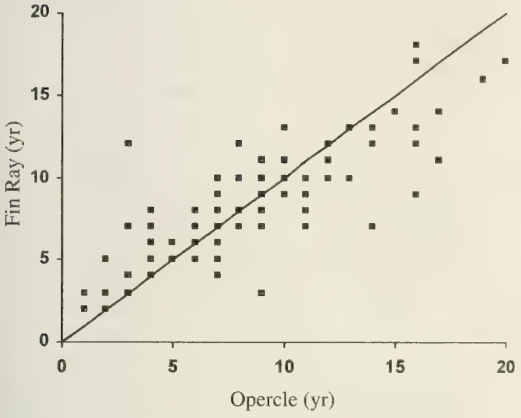
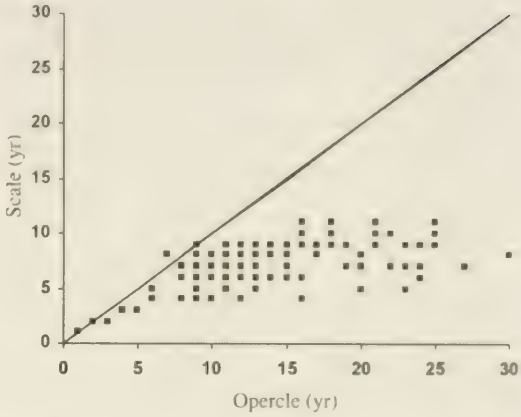


FIGURE 3. Comparison of Shorthead Redhorse opercle-based age estimates with those from scales (top) and pectoral fin rays (bottom). Opercle vs. scale CV (mean ± SE): 35.5 ± 2.8. Opercle vs. pectoral fin ray CV: 9.4 ± 1.0.



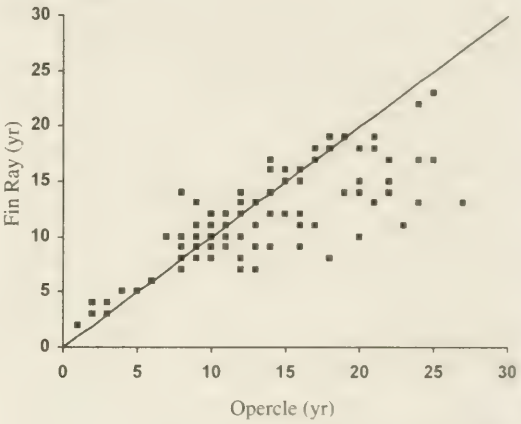


FIGURE 4. Comparison of Silver Redhorse opercle based age estimates with those from scales (top) and pectoral fin rays (bottom). Opercle vs. scale CV (mean ± SE): 31.8 ± 2.0. Opercle vs. pectoral fin ray CV: 25.3 ± 3.2.

opercle-based estimates. Underestimation of age resulting from the use of scales may also apply to maximum ages reported for Silver Redhorse in Alabama and Iowa (Meyer 1962; Hackney et al. 1970). For similarly sized Silver Redhorse in Ontario, scale-based age estimates were as much as 18 years lower than those from opercles.

Monitoring the status of imperiled redhorse species in Ontario will require non-lethal sampling methods. Results from this study indicate that pectoral fin rays are suitable for monitoring recruitment and detecting changes in population age structure. However, estimates of growth, mortality and maximum age are expected to be inaccurate. If more accurate estimates are necessary to meet monitoring objectives, opercles could be removed from a subset of the individuals sampled and used to: (1) back-calculate growth rates from measurements of annuli radii; and (2) adjust pectoral fin ray based age estimates of large (and presumably older) individuals.

Acknowledgments

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A Rare Case of Completely Ambicoloured Atlantic Halibut, *Hippoglossus hippoglossus*, from the Lower St. Lawrence Estuary, Quebec

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Chabot, Denis, and Roberta Miller. 2007. A rare case of completely ambicoloured Atlantic Halibut, *Hippoglossus hippoglossus*, from the lower St. Lawrence estuary, Quebec. Canadian Field-Naturalist 121(1): 35–39.

An Atlantic Halibut (*Hippoglossus hippoglossus*) (41.4 cm fork length) with the same pigmentation on the blind side as on the ocular side (ambicoloration) was captured in the lower St. Lawrence estuary, Canada, on 24 June 2004. This specimen represents the most extreme case of ambicoloration published for this species to date. As in other cases of extreme ambicoloration, this specimen shows other signs of abridged metamorphosis and reduced asymmetry, such as incomplete migration of the left eye and a hooked dorsal fin. Studies of hatchery-reared larvae have shown that the most common cause of malpigmentation, including ambicoloration, in halibut is a diet containing inadequate amounts and proportions of essential unsaturated fatty acids shortly before metamorphosis. Even though not expected to be common in the wild, inadequate diet for a short duration before metamorphosis is the most likely cause of ambicolouration in wild halibut.

Key words: Atlantic Halibut, *Hippoglossus hippoglossus*, ambicolouration; malpigmentation, metamorphosis, eye migration, hooked dorsal fin, St. Lawrence estuary, Quebec.

Flatfish larvae are normally pigmented on both sides, whereas juveniles and adults are usually pigmented only on their ocular side. Once metamorphosis begins, larval-type melanophores (pigment cells containing melanin) on the blind side go through cytolysis whereas developing adult melanophores differentiate on the ocular side (Norman 1934; Venizelos and Benetti 1999; Bolker and Hill 2000). However, some pleuronectiforms both wild and hatchery reared, have abnormal pigmentation patterns (Wheeler 1969; Gartner 1986; Bolker and Hill 2000). Malpigmentation ranges from deficiencies of pigmentation on the ocular side (hypomelanosis or pseudoalbinism) to an excess of pigmentation on the blind side (hypermelanosis or ambicoloration) (Venizelos and Benetti 1999; Bolker and Hill 2000).

Norman (1934) divided ambicolouration into three categories: staining, spotting and true ambicoloration. Staining is the development of irregular pigmented patches on the blind side that are lighter than the pigmentation of the eyed side and lack the characteristic spots and markings of the latter. Spotting is the presence of black or brown spots, in irregular or regular arrangement; the spots that are present occupy the same position as the characteristic dark spots found on the ocular side. Finally, true ambicoloration is when the coloring on the blind side is the same as that on the ocular side; true ambicoloration is often partial, involving the posterior part of the body while the head and a variable proportion of the anterior part remain white on the blind side. Very occasionally flatfish are completely ambicolored (Norman 1934).

Juvenile and adult Atlantic Halibut, *Hippoglossus hippoglossus*, are olive or slaty brown with some black on the ocular (right) side and strikingly white on the blind side, although the blind side can be of a more or less uniform grayish cast, or blotched with gray or even red, in older specimens (Gudger and Firth 1935; Scott and Scott 1988; Collette and Klein-MacPhee 2002). Here we describe a completely ambicoloured Atlantic Halibut and review the few past mentions of malpigmented Atlantic Halibut as well as studies dealing with possible causes of malpigmentation in general, and ambicolouration in particular.

Results

An Atlantic Halibut with a total length (TL) of 42.6 cm and a fork length (FL) of 41.4 cm was captured by bottom-trawling in the lower St Lawrence estuary, 48°56'N, 67°26'W on 24 June 2004 (depth = 90-100 m, temperature = 0.5-1.1°C). Nine normally-pigmented *H. hippoglossus* were captured during the 56 sets fished over 6 days in this area. No ambicolored Atlantic Halibut was captured during the annual survey of the northern Gulf of St. Lawrence and lower estuary for the years 1990-2005. This bottom-trawl survey was conducted by the Department of Fisheries and Oceans Canada in August and early September every year. A total of 310 normally-pigmented *H. hippoglossus* was captured in 3715 trawl sets during this period.

The blind side of the ambicoloured fish was exactly the same colour as the ocular side, except for a lack of pigmentation on the distal half of the pectoral fin and one small white spot (1-2 mm) in the middle of the left side. The anterior end of its dorsal fin had grown into a hook detached from the head. Furthermore, the left eye had not completed its migration to the right side and remained partly visible from the blind side. Photos of the ocular and blind sides of this fish are shown in Figure 1. For comparison, a normal Atlantic Halibut

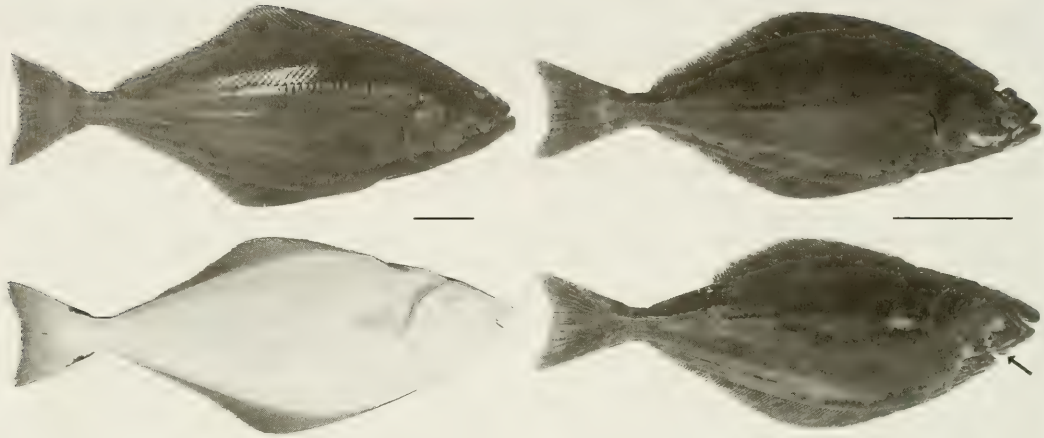

FIGURE 1. Ocular (top) and blind side (bottom) of a normal (left) and ambicoloured (right) Atlantic Halibut, *Hipoglossus hippoglossus*. A 10-cm scale bar is shown next to each fish. The left eye of the ambicoloured fish has not completed its migration and is partly visible from the blind side (arrow). Pale areas on the blind side of the head of ambicoloured fish are caused by light reflection: pigmentation was the same as on the ocular side.

(85.9 cm TL and 84.7 cm FL [Fork Length]) captured at about the same location on 25 June 2004 (depth = 120-130 m, temperature = 1.8-2.0°C) is also shown.

Discussion

An almost completely ambicoloured Atlantic Halibut was described by Gudger and Firth (1935). Like the present specimen, it had a hooked dorsal fin and incompletely rotated left eye. Unlike the present specimen, about 30% of the blind side of the head was white, and except for the distal half of the pectoral and caudal fins, the remainder of the blind side was darker in colour than the ocular side, almost black. Gudger and Firth (1937) mention two other *H. hippoglossus* that were partially ambicoloured and reversed (the eyes were on the left side). A literature search revealed no further occurrences of wild ambicoloured halibut. However, malpigmentation is common in hatchery-reared Atlantic halibut and ambicoloration is often accompanied by a hooked dorsal fin and incomplete eye migration (Næss et al. 1995; Pittman et al. 1998).

Bolker and Hill (2000) discussed two possible explanations for malpigmentation. The first hypothesis asserts that the development of the normal pigmentation asymmetry in flatfish is associated with the development of a fundamental left-right distinction. The lack of development of adult melanophores on the blind side is not due to the lack of precursor cells, but rather to a difference in the histological structure of the skin on both sides of the fish (Seikai and Matsumoto 1994). Failure of this differentiation to develop can prevent adult melanophore development on the ocular side and result in pseudoalbinism. Although not as thoroughly studied, ambicoloration could also be explained in this manner. The second hypothesis to explain malpigmentation, or at least pseudoalbinism, involves dietery-based abnormal development of the retina. The resulting visual defects are thought to lead to a failure of a hormonal signal necessary for melanophore development on the ocular side. Bolker and Hill (2000) noted that the two hypotheses were not mutually exclusive.

Incomplete eye migration could be the cause of ambicoloration if optical signals were still interpreted by the brain as coming from the blind side, resulting in ocular-side melanophore development on the blind side. However, this hypothesis is not supported by the results of studies of hatchery reared Atlantic Halibut, where ambicoloration was found in fish that had complete eye migration (e.g., Hamre et al. 2002), and conversely, both normally coloured and ambicoloured Atlantic Halibut exhibited a lack of eye migration (Pittman et al. 1998).

In wild fish, partial ambicoloration is usually not associated with other abnormalities, whereas Norman (1934) and Gudger and Firth (1936) noticed that in almost completely ambicoloured flatfish with pigmentation on at least 25-35% of the blind side of the head, eye migration was usually incomplete and the anterior end of the dorsal fin was hooked. Incomplete eye migration and the presence of a hooked dorsal fin are expected to occur together: pterygiophores (bones supporting the dorsal fin) normally expand towards the snout during metamorphosis, after the left eye clears the dorsal crest (Norman 1934; Gudger and Firth 1935; Brewster 1987). Incomplete eye migration, where the left eye does not clear the dorsal crest, prevents normal pterygiophore expansion. Furthermore incomplete eye migration is accompanied by incomplete torsion of the neurocranium, resulting in the formation of a hooked dorsal fin (Sæle et al. 2004). Total or nearly

total ambicoloration is also accompanied by other abnormalities such as pectoral fins that are more equal in length than in normally pigmented fish, and the presence of the same type of scales on the coloured areas of the blind side as those on the ocular side.

As pointed out by Norman (1934), the anterior part of the head is coloured only in the most complete cases of ambicoloration and is also the most asymmetrical part of a flatfish. Thus the available observations indicate that the gradient in ambicoloration corresponds to a gradient in the level of perturbation during metamorphosis. Pigmentation of a small proportion of the blind side is a minor developmental defect, whereas complete ambicoloration is a sign of more profound disturbances resulting in a less complete metamorphosis, i.e., a reduction of asymmetry including incomplete eye migration and almost complete pigmentation of the blind side. However, the causes of these developmental defects are not well understood, especially for wild fish.

Many possible causes of malpigmentation have been proposed that involve flatfish larvae before or during metamorphosis, including diet, water quality, stocking density, extreme temperature, UV light, stress and genetic factors (for reviews see Gartner 1986; Seikai and Matsumoto 1994; Venizelos and Benetti 1999; Bolker and Hill 2000; Hamre et al. 2005). Inadequate diet is now thought to be the most important cause of malpigmentation. Pseudo albinism was a very common problem when hatcheries started to grow halibut larvae and fed them artemia. This was alleviated when larvae were fed a natural copepod-based diet during a specific premetamorphic stage that constitutes a critical period (Næss et al. 1995; Næss and Lie 1998; Shields et al. 1999). In particular, levels and proportions of essential unsaturated fatty acids are important for successful pigmentation. Artemia are low (in proportion of total lipids) in docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) and high in arachidonic acid (ARA) compared with copepods (Næss et al. 1995; Copeman et al. 2002; Hamre et al. 2005). High levels of DHA resulting in a DHA/EPA ratio > 1, reduced levels of ARA and high EPA/ARA ratios decrease the incidence of pseudoalbinism, incomplete eye migration and hooked dorsal fin (Næss et al. 1995; McEvoy et al. 1998a; Næss and Lie 1998; Shields et al. 1999; Hamre et al. 2002). Other nutritional differences between artemia and copepods may contribute to pigmentation, such as the greater proportion of polar lipids (McEvoy et al. 1998b), vitamin A (or its precursors, carotenoid compounds) and iodine (Hamre et al. 2005) in copepods.

Less attention has been paid to the development of ambicoloration. It can be voluntarily produced in the Japanese Flounder, *Paralichthys olivaceus,* by immersing larvae in water containing retinoic acid (Haga et al. 2005). Ambicoloration is an undesirable trait in hatcheries that is not normally induced voluntarily, but rather occurs spontaneously at incidence rates that depend on diet. Most diets that reduce the incidence of pseudoalbinism also increase the incidence of hyper melanosis of the blind side (for a review, see Haga et al 2004). For instance, an excess of vitamin D_3 (Hasegawa et al. 1998; Haga et al. 2004) or A (Miwa and Yamano 1999) can increase the rate of ambicoloration in the Japanese Flounder. In Atlantic Halibut, copepod-based diets sometimes resulted in ambicoloration for up to 30-40% of the fish (Shields et al. 1999; Hamre et al. 2002; Hamre et al. 2005), but in other studies it did not (Næss et al. 1995; Næss and Lie 1998). This is likely the result of variability in nutritional properties of the copepods used, as the quantities and ratios of unsaturated fatty acids, vitamins and other nutrients changed between batches or size-classes of copepods within and between studies (e.g., Næss et al. 1995; McEvoy et al. 1998a; Shields et al. 1999; Hamre et al. 2002). Diet-induced ambicoloration is conceivable in wild halibut as well: hatching time, egg condition and environmental conditions all influence when larvae begin to metamorphose and the availability and quality of prey items. Laboratory studies have shown that the critical period during which diet influences the development of post-metamorphic pigmentation is short, making it possible for wild fish to have a suboptimal diet near the beginning of metamorphosis and become ambicoloured.

Malpigmentation can also occur in post-metamorphic flatfish. Many wild fingerlings of Speckled Flounder (*Paralichthys woolmani*) that were normally pigmented when captured developed white spots on their ocular side within a few days. Most of them returned to a normal pigmentation within one year, except for a few that retained some pigmentation on their blind side (Benetti 1997; Venizelos and Benetti 1999). Light reaching the blind side where it is not in contact with the bottom, and lack of sediment in which fish can bury themselves can also result in some pigmentation on the blind side of flatfish (Cunningham 1893; Ottesen and Strand 1996). However these are examples of staining, not ambicoloration. True ambicoloration appears to be in place soon after metamorphosis.

It is difficult to assess whether factors leading to malpigmentation in hatchery-reared halibut would do so in the wild, or if these factors are even relevant in the wild. Halibut larvae likely encounter appropriate prey items in the wild. However, considering the high incidence of malpigmentation when diet is inappropriate for only a few days in hatcheries, and the fact that non-diet related causes of malpigmentation in captive Atlantic Halibut (light, sediment type, stocking density, etc.) are even less likely to be problematic in the wild, diet is the most likely of the known causes of malpigmentation to occur in the wild. Other possible causes, such as a genetic causes, remain possible, however. True albinism (i.e., presence of red eyes) is inheritable in the Japanese Flounder (Shikano 2005), but diet appears much more important than genetic factors in the development of pseudo-albinism and ambicolouration (Seikai and Matsumoto 1994).

Few wild ambicoloured Atlantic Halibut have been reported, but reporting rate is unknown. Reporting malpigmentation should be encouraged in scientific surveys for this species as well as others to assess incidence and mortality rate of ambicoloured fish and improve our understanding of the causes of ambicolouration in Atlantic Halibut, and of taxonomically related incidence rates in flatfish (e.g., Díaz de Astarloa et al. 2006).

The specimen presented in this study has been preserved and is part of the Maurice-Lamontagne Institute Collection (accession number 11633).

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Micro-Propagation of White-top Aster, *Sericocarpus rigidus*, a Threatened Species from the Garry Oak Ecosystem in British Columbia

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A study was undertaken to examine the feasibility of using micro-propagation techniques to regenerate White-top Aster (*Sericocarpus rigidus*), a threatened species native to the Garry Oak ecosystem in coastal British Columbia. Shoot multiplication from explants was compared in three different basal media formulations. The effects of varying IAA (indole-3-acetic acid) and kinetin on shoot production were also investigated using one of the three basal media. Shoot production was most successful on modified MS (Murashige and Skoog) media containing various concentrations of BAP (benzylaminopurine) and GA_3 (gibberellic acid), followed by media containing IAA and kinetin at concentrations of 2 mg l^{-1}. Root formation occurred readily on modified MS media with IAA and reduced macronutrient and micronutrient concentrations. The study showed that *S. rigidus* can be successfully propagated using *in vitro* shoot multiplication.

Key Words: *Sericocarpus rigidus*, *Aster curtus*, White-top Aster, micro-propagation, Garry Oak ecosystem, British Columbia.

The Garry Oak ecosystem has a geographic distribution that spans the west coast of North America, from southwestern British Columbia to southern California. In recent years, the survival of this ecosystem in Canada has been threatened by fire suppression and by residential, industrial and agricultural development. These activities have resulted in loss of species habitat, habitat degradation and the spread of invasive exotic species (Garry Oak Ecosystem Recovery Team 2002*). The Garry Oak ecosystem contains more plant species than any other terrestrial ecosystem in coastal British Columbia, and many plants that live in the ecosystem do not occur elsewhere in Canada. It is now estimated that less than 5% of all Garry Oak sites remain in their natural state (Garry Oak Ecosystem Recovery Team 2002*).

The White-top Aster, *Sericocarpus rigidus* (formerly *Aster curtus*), is an herbaceous perennial species of Asteraceae native to low elevation grasslands in the Pacific Northwest in the United States and the associated Garry Oak ecosystem on Vancouver Island, British Columbia (Clampitt 1987). Due to the serious loss of habitat, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated White-top Aster as a threatened species in 1996, and the species is now protected under the Species At Risk Act (SARA) (Environment Canada 2006*). *Sericocarpus rigidus* produces underground rhizomes, and as a result, occurs in patches which can vary tremendously in size. Shoots emerge from rhizomes in April, flower in July and August, then die back in the autumn. Seedlings are rarely, if ever, observed, making rhizomes the major form of propagation (Douglas and Illingworth 1997). Even though *S. rigidus* produces an abundance of seeds, viability is low and often uneven. In pollination studies, Clampitt (1987) found that excluding pollinators by bagging ramets significantly reduced the percentage of viable seeds (measured with tetrazolium chloride) from 20% in the unbagged treatment to 5% in the bagged. Bigger (1999) found that exposed and hand-pollinated flowers generally had the same number of viable seed (as tested with tetrazolium chloride), but differences in seed viability between hand-pollinated and exposed plants varied greatly among sites, possibly due to pollinator limitations in some patches. Patch size was also found to influence the degree of predation by insects. Overall, seed viability varied from 0 to 83%. In a field comparison of open pollinated, between patch pollinated, within patch pollinated and pollination excluded treatments, Giblin (1997) found that open and between patch pollination treatments produced significantly more filled seed (39% and 35%, respectively) than within patch and pollination exclusion treatments (18% and 9%, respectively). In terms of conditions required for germination, Clampitt (1987) showed that stratification and exposure to light increased germination. Ehret et al. (2004) have shown that the seeds required an 8–12 week period of stratification for germination and seedlings are slow to establish. Even so, Giblin and Hamilton (1999) suggest that the reproductive biology of the species does not contribute to its rarity.

Sericocarpus rigidus was one of three species "at risk" plants studied at the Pacific Agri-Food Research Centre (PARC) with the objective of developing propagation methods that would allow for the generation of plant material that could be reintroduced into protected Garry Oak ecosystems, parks and ecological

reserves or made available to native plant nurseries. Because of the difficulties associated with seed germination, micro-propagation was studied with the objective of developing a method that could rapidly and reliably produce plantlets.

Materials and Methods

Plant Material

Seeds were collected from two patches of *S. rigidus* growing at an elevation of 220 m on Mt. Tzuhalem (48°47'N, 123°38'W) on Vancouver Island in September 2001 and from another patch at the same location in September 2002. The collection sites were 100 to 300 m apart. Given the close proximity, all plants may have been derived from the same clone. Collected seed count varied from 50 to 200 per plant. Seeds from 2001 were dried and stored at room temperature in the dark for one year. In September 2002, all seeds were placed in the dark in a cooler at 4°C. In October 2002, 15 to 30 seeds from each patch were placed on damp filter paper in petri dishes and incubated in a growth chamber maintained at 20°C and 14/10 h light/dark. After three weeks, only four seeds had germinated and all were collected from the same patch in 2001. These were potted in 10 cm pots containing Sunshine Mix 4, (Sun Gro Horticulture Inc., Vancouver, British Columbia) and were over-wintered in a greenhouse. In May 2003 the seedlings were hardened off in a cold frame for four weeks before being transplanted into a silt loam soil in irrigated raised beds at PARC. After one season of growth and flowering, seeds were collected from those plants in October 2003, and after air drying, were stored in a cooler at 4°C for 3 months. Surface sterilization of 10 seeds was conducted by suspending the seeds in a 5% solution of PPM (Plant Preservative Mixture) (Plant Cell Technology Inc., Washington D.C., USA) and deionized water (v/v) in a beaker on a shaker for 24 h. Seeds were aseptically transferred to a petri dish containing a 1.5% solution of sterile Bacto agar in deionized water (w/v). The petri dish was sealed with parafilm and placed in a plastic bag in a refrigerator at 3°C in the dark.

After nine weeks at 3°C, one seed germinated. This was the only seed that germinated during the next five months. The seedling was removed from the petri dish under sterile conditions and placed in a 350 ml jar containing half-strength MS (Murashige and Skoog 1962) media containing 1.0 mg L^{-1} IAA and 0.1 mg L^{-1} kinetin. The jar was placed in a growth room maintained at 22–25°C with a 16/8 h light/dark cycle using fluorescent light with a PPFD (photosynthetic photon flux density) of ~50 µE m^{-2} s^{-1}. After five weeks, the fully developed, healthy seedling was transferred to a modified MS medium containing half the concentration of ammonium nitrate (825 mg•L), 2.0 mg•L^{-1} IAA and 2.0 mg l^{-1} kinetin. After four weeks on this medium, shoot and roots were excised and cultured on fresh media. Cultures were maintained by bimonthly transfer to fresh media until enough shoots were generated to conduct shoot multiplication and rooting experiments. The excised root tissue failed to grow after being removed from the shoot and was discarded.

Shoot Induction

A replicated shoot multiplication experiment was initiated to determine the effects of various concentrations of IAA plus kinetin or BAP plus GA_3 on the growth of explant shoots produced on modified MS media. The experimental design was a randomized complete block design consisting of seven media treatments with six replicate jars, each containing five explants. The experiment included three modified MS basal medium (BM) formulations with each formulation containing a different concentration of macronutrients, micronutrients and organic additives (Table 1). BM1 was a formulation used in earlier micropropagation media development using the cultivated violet species, *Viola praemorsa* (Ehret et al. 2004). BM2 and BM3 were modified MS media used routinely in the PARC strawberry and raspberry breeding programs for shoot proliferation. The ammonium nitrate concentration of BM1 was half that of the other media because higher rates of ammonium nitrate have been found to be toxic to cultures of some plant species because the uptake of ammonium ions can acidify the medium and increase the frequency of vitrification (Slater et al. 2003). BM1 was the basal media used in media treatments 1 through 5 and it was supplemented with five combinations of IAA and kinetin as follows: 0.5 mg•L^{-1} IAA + 1.0 mg•L^{-1} kinetin (M1), 0.5 mg•L^{-1} IAA + 2.0 mg•L^{-1} kinetin (M2), 2.0 mg•L^{-1} IAA + 1.0 mg•L^{-1} kinetin (M3), 2.0 mg•L^{-1} IAA + 2.0 mg•L^{-1} kinetin (M4) and 3.0 mg•L^{-1} IAA +2.0 mg l^{-1} kinetin (M5). M4 was the initial shoot multiplication media used to generate plant material for the experiment. BM2 was the basal media used in treatment 6 (M6) and it was supplemented with 2.5 mg•L^{1} BAP and 0.01 mg•L^{-1} GA_3. BM3 was the media used in treatment 7 (M7) and it was supplemented with 1.0 mg•L^{-1} BAP and 0.01 mg•L^{-1} GA_3. The ferrous sulphate and Fe-EDTA supplied in BM1 and BM2 was replaced by Sequestrene 138 (Becker Underwood Inc., Ames, Iowa, USA) in BM3.

The pH of all media treatments was adjusted to 5.6–5.7 and the media were then dispensed into 350 mL jars which were covered with cellophane and autoclaved. Explants which had a mean weight of 0.164 g ± 0.008 (SE), were aseptically transferred into treatment jars which were incubated in a growth room maintained at 22–25°C with a 16/8 h light/dark cycle using fluorescent light with a PPFD of ~50 µE m^{-2} s^{-1} for four weeks. After four weeks, the number of explants that produced shoots and roots, the number of shoots produced per explant, and shoot and explant fresh weights were recorded.

Root Induction

A separate rooting experiment was conducted using BM4 (Table 1) which is used in the PARC berry breed-

TABLE 1. Four modified Murashige and Skoog (MS) basal media (BM) formulations used for *S. rigidus* culture. Rates are expressed in mg•l^{-1} with the exception of Plant Preservation Mixture, which is expressed in ml l^{-1}.

	Induction Media			
	Shoot			Root
	BM1	BM2	BM3	BM4
Macronutrients				
Ammonium nitrate	825	1650	1237	464
Calcium chloride (anhydrous)	332	332	332	332
Magnesium sulphate ($MgSO_4 \cdot 7H_2O$)	370	370	370	370
Potassium phosphate	170	170	170	64
Potassium nitrate	1900	1900	1425	534
Micronutrients				
Boric acid	6.2	6.2	6.2	3.1
Cobalt chloride	0.025	0.025	0.025	0.013
Cupric sulphate	0.025	0.025	0.025	0.013
Ferrous sulphate	27.8	27.8	–	–
Manganese sulphate	22.3	22.3	22.3	11.2
Potassium iodine	0.83	0.83	0.83	0.42
Sodium molybdate	0.25	0.25	0.25	0.13
Zinc sulphate	8.6	8.6	8.6	4.3
Na_2EDTA	37.2	37.2	–	–
Sequestrene 138	–	–	200	100
Sodium phosphate ($NaH_2PO_4 \cdot H_2O$)	–	170	170	85
Organic Additives				
Sucrose	20	30	30	30
myo-inositol	1000	100	100	100
Nicotinic acid	0.5	–	–	–
Pyridoxine·HCL	0.5	–	–	–
Thiamine	0.1	0.8	0.8	0.4
Glycine	20	–	–	–
Adenine	–	80	80	–
Plant Preservation Mixture	2	2	2	2
Gerlite guar gum	2	2	2	2

ing program for root development. Fifteen shoot samples initiated on M4 were placed on the rooting medium containing 1.0 mg•L^{-1} IAA. After four weeks, rooted plants were transferred to Sunshine Mix 4 potting mix and moved to a greenhouse where they were acclimatized.

Statistical Analysis

Data were analysed using the general linear model procedure in SAS (SAS Institute, Cary, North Carolina, USA), for one-way analysis of variance (ANOVA). All independent factors were fixed. Where ANOVA results were significant, treatment means were separated by Duncan's multiple range tests. Data expressed in percentages were transformed by arcsin transformations before statistical analysis.

Results and Discussion

In general, explants grew rapidly in culture, with extensive shoot multiplication (Figure 1 a, b). After four weeks of culture, explant survival ranged from 83.3 to 100 percent with no significant survival differences among media treatments (Table 2). The percentage of surviving explants that produced shoots ranged from 61 to 100%. Just over 60% of M1 and M3 explants produced shoots compared to 90–100% of explants cultured on M4–M7. In addition, explants cultured on M1, M2 or M3 produced roots while being cultured on shoot multiplication media (data not presented). M1 and M3 which had the lowest concentrations of kinetin produced the greatest number of roots, 13 and 20 % respectively. These results suggest that aster media should contain kinetin at minimal rates of 2.0 mg•L^{-1} to avoid root initiation during the shoot multiplication stage. This supports previous recommendations that kinetin be added to a medium for cell division, shoot multiplication and axillary bud proliferation while IAA should be added to promote cell enlargement, root initiation and adventitious bud formation (Kyte and Klein 1999).

Mean explant plus shoot weights ranged from 0.241 to 0.855 grams. No statistically significant differences were observed among BM1 treatments. M6 produced a significantly greater biomass than all other media, followed by M7 which had a significantly greater biomass than M1 to M3 (Table 2, Figure 1c). Explants and shoots cultured on M6 appeared slightly chlorotic compared to those cultured on M7 which were the darkest green of all treatments (data not presented). Explants cultured on M2 and M3 were the least vigorous; explant and shoot leaves appeared mottled and there

FIGURE 1. A. *Seriocarpus rigidus* explant on culture media after two weeks in culture. B. Explants and developed shoots on media after 4 weeks. C. Representative samples of explants and shoots cultured on seven media treatments after 4 weeks of culture. Treatment labels 1 through 7 represent treatments M1 through M7, respectively. D. Four-month-old rooted aster plants in the greenhouse.

were several dead leaves at the base of the explants.

The number of shoots per surviving explant ranged from 1.72 to 6.19 shoots per explant (Table 2). Within the BM1 treatments, M2 and M3 produced significantly fewer shoots than M4. Treatments M6 and M7, both of which contained BAP and GA_3 and which were on BM2 and BM3, respectively, produced a greater number of shoots per explant than most BM1 treatments containing combinations of IAA and kinetin.

The mean weight of individual shoots cultured on the different media ranged from 0.037 to 0.097 grams per shoot. Few consistent differences were observed among the five BM1 treatments. Compared to those treatments, M6 (on BM2 with BAP and GA_3) produced shoots with the greatest weight. Despite some differences among BM1 treatments, the results show

that the ratio and the concentration of IAA and kinetin in BM1 did not have a consistent effect on overall shoot multiplication. Shoots were small and difficult to handle after four weeks of culture. Extending the culture time from four to five weeks would likely have increased shoots to a size that would have made them easier to transfer and a more desirable size for rooting.

Root initiation was 100% on the BM4 medium (data not shown). Roots appeared on the shoots after 7 days of culture, and after 4 weeks a healthy root system had fully developed. The rooted plants were easily acclimatized to a greenhouse environment and showed vigorous growth (Figure 1d). Other methods to induce root development were not attempted since this technique was so highly successful.

Micro-propagation methods for commercially important species of Asteraceae such as sunflower (*Helianthus annuus*) employ a variety of techniques to regenerate plants (Alibert et al. 1994). There are also methods to micro-propagate other Asteraceae species of commercial value, such as feverfew (*Tanacetum parthenium*) (Simmons 1998), marigold (*Tagetes erecta*) (Vanegas et al. 2002), *Echinacea pallida* (Koroch et al. 2003) and safflower (*Carthamus tinctorius*) (Orlikowska and Dyer 1993). These techniques have increasingly been used on medicinally important Asteraceae species such as goldenrod (*Solidago virgaurea, S. canadensis, S. gigantea* and *S. graminifolia*) (Kelemba and Thiem 2004) and those which are rare, such as *Saussurea obvallata* (Joshi and Dhar 2003). In Canada, micro-propagation of the Gulf of St. Lawrence Aster, a rare species in Prince Edward Island, has been shown to have potential in conservation efforts (Stewart and Lacroix 2001).

Meristem culture has been extensively used for the clonal propagation of horticultural plants. Since the constituent cells of meristems are genetically stable, plants regenerated by *in vitro* culture of shoot apices without the callus-mediated process of organogenesis should result in the recovery of genetically identical progeny. Because the culture was started from a single seed and mass regenerated in tissue culture, genetic variability is limited. *Sericocarpus rigidus* propagates clonally in the wild by underground rhizomes, so *in vitro* mass clonal propagation could be a good strategy for preservation and reintroduction of this threatened species.

Our study is the first to show that the threatened Asteraceae species, *S. rigidus*, can also be successfully propagated using micro-propagation techniques. Only one germinated seed was available for use in the study. However, by its very nature, micro-propagation works at the level of single seeds or explants, so our situation is not atypical. The genetic variability of the Mt. Tzuhalem population of *S. rigidus* is not known, but since the plant occurs in clonal patches, it is unlikely that other seeds of *S. rigidus* would respond differently to micro-propagation. The best results for shoot mul-

TABLE 2. Growth and survival of *Sericocarpus rigidus* explants on basal medium amended with growth regulators after four weeks in culture.

Treatment	Basal medium	Growth regulators ($mg \cdot L^{-1}$)	Explant survival (%)	Surviving explants producing shoots (%)	Explant plus shoot weight (g)	Number of shoots per surviving explant	Shoot weight (g/shoot)
		IAA + kinetin					
M1	BM1	0.5 + 1.0	100	63.3 ± 6.1 b	0.262 ± 0.02 c	2.68 ± 0.29 cd	0.040 ± .005 cd
M2		0.5 + 2.0	86.7	81.7 ± 6.4 ab	0.278 ± 0.02 c	1.94 ± 0.13 d	0.037 ± .004 d
M3		2.0 + 1.0	83.3	61.1 ± 17.1 b	0.241 ± 0.04 c	1.72 ± 0.14 d	0.070 ± .013 bc
M4		2.0 + 2.0	100	90.0 ± 6.8 a	0.439 ± 0.07 bc	4.13 ± 0.50 bc	0.056 ± .009 bcd
M5		3.0 + 2.0	93.0	90.0 ± 4.4 a	0.379 ± 0.08 bc	2.97 ± 0.58 cd	0.056 ± .007 bcd
		BAP + GA_3					
M6	BM2	2.5 + 0.01	100	96.7 ± 3.3 a	0.855 ± 0.13 a	6.19 ± 0.96 a	0.097 ± .009 a
M7	BM3	1.0 + 0.01	96.7	100.0 ± 0 a	0.542 ± 0.04 b	4.63 ± 0.47 ab	0.079 ± .005 ab
Significance			NS	**	**	**	**

Means (± SE) within columns followed by the same letter are not significantly different. NS: Non-significant or *significant at $P < 0.05$ and **0.01, respectively.

tiplication were obtained with combinations of BAP and GA_3, a regime which has not often been used in other Asteraceae studies. Further work is required to determine the optimum basal medium formulation to use with the most successful combinations of BAP plus GA_3 in order to generate the greatest number of vigorous *S. rigidus* shoots. Additionally, research with vegetative tissue as a source of explants, rather than seeds, could be conducted in order to avoid the time and difficulties associated with seed germination. However, from a conservation point of view, harvesting vegetative tissue, particularly rhizomes, from a threatened or endangered species may be less desirable than harvesting seeds because of damage to the plant and disturbance of the site.

The costs of micro-propagation were not evaluated against more conventional propagation techniques. Tissue culture is cost effective and is used commercially in the propagation of many plants. Although it requires more knowledge and extra capital to start a micropropagation operation, the rate of propagation is much faster than in conventional propagation. Given that hundreds of propagules of an endangered or threatened species may be generated using micro-propagation, the effort seems reasonable.

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Pattern and Potential Causes of White-faced Ibis, *Plegadis chihi*, Establishment in the Northern Prairie and Parkland Region of North America

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The Northern Prairie and Parkland Waterbird Conservation Plan calls for renewed attention to determining the current status of waterbird populations, their distributions, and conservation needs. It highlights the need for baseline information on the White-faced Ibis (*Plegadis chihi*). In response, we examined the historical and current distribution of the ibis in North Dakota and summarized first sightings and nest records for the provinces and other states composing the northern prairie and parkland region. The establishment of breeding colonies of White-faced Ibis here may be due to climate and precipitation patterns, invasion and spread of Narrowleaf Cattail (*Typha angustifolia*), changes in agricultural practices, habitat loss and range expansion in the southern and western portions of the species' range, and increases in ibis populations in the Intermountain West. We placed special emphasis on North Dakota, a state for which there is scant published information concerning the current status of this species. In recent decades, the ibis has become a regular breeding-season resident in North Dakota and in other areas of the northern prairie and parkland region. From 1882 to 2002, there were 145 reports of one or more White-faced Ibis in North Dakota, including 93 reports during the breeding season (15 May to 31 August), 49 during the non-breeding season (1 September to 14 May), and three for which the season of occurrence was not reported. Prior to the 1960s, there were only three records of the species in North Dakota. Observations of White-faced Ibises in North Dakota increased dramatically between the 1960s and the early 21st century, and the species has been observed nearly annually since 1971. The first White-faced Ibis nesting activity in the state was recorded in 1978, and to date, there have been 21 known records of nesting activity in the state. The species nested in large (>300 ha) semipermanent or permanent wetlands within mixed-species colonies ranging in areal extent from small (0.1 ha) to fairly large (27 ha), and colonies were located in patches of emergent vegetation dominated by cattails (*Typha*) and bulrushes (*Scirpus*). We classify the White-faced Ibis as a fairly common migrant and a locally uncommon breeder east of the Missouri River and a casual migrant west of the Missouri River.

Key Words: White-faced Ibis, *Plegadis chihi*, colonial-nesting waterbird, distribution, status, northern prairie and parkland region, North Dakota.

The White-faced Ibis (*Plegadis chihi*; hereafter ibis) is a wading bird that nests in wetlands with emergent vegetation and forages in shallow wetlands, flooded hay meadows, or agricultural fields (Ryder and Manry 1994). Northernmost populations undertake regular north-south migrations, whereas populations in Texas and Louisiana are mainly year-round residents (Ryder and Manry 1994). Extralimital wanderings seem to be more prevalent before the nesting season than afterward and may represent individuals seeking new nesting areas when traditional sites are dry or have been destroyed by humans (Ryder 1967; Ryder and Manry 1994). During the twentieth century, numerous sightings of the species east and north of its historical range were reported (Sabo 1992; Jorgenson and Dinsmore 2005).

The recently completed North American Waterbird Conservation Plan (Kushlan et al. 2002) and its regional offshoot, the Northern Prairie and Parkland Waterbird Conservation Plan (NPPWCP) (Beyersbergen et al. 2004), called for renewed attention to determining the current status of waterbird populations, their distributions, and conservation needs. The NPPWCP emphasized that information on the breeding distribution of ibis in the northern prairie and parkland region (portions of Alberta, Saskatchewan, Manitoba, Montana, North Dakota, South Dakota, Minnesota, Iowa, and Nebraska) is needed to serve as a baseline for future monitoring needs (Beyersbergen et al. 2004). In response to these information needs, we examined the historical and current distribution of the ibis in North Dakota and summarized first sightings and nesting records for the provinces and states composing the northern prairie and parkland region. We placed special emphasis on North Dakota, a state for which there is scant published information concerning the current status of this species.

Lokemoen (1979) and Schmidt (1980a) summarized the first occurrences and nest records of White-faced

Ibis in North Dakota. Sabo (1992) described the status, range, first occurrences, and first nesting observations for some Great Plains states and Canadian provinces. Goossen et al. (1995) provided a detailed list of observations and breeding records for the species throughout Canada. Jorgenson and Dinsmore (2005) provided an update of breeding records throughout the Great Plains. In this paper, we summarize the reported occurrences of White-faced Ibis in North Dakota up to 2002, and we report nest records through 2003, beyond which time the U.S. Fish and Wildlife Service (USFWS) no longer quantified colony and nest numbers. We discuss factors influencing the species' expansion into the state and provide data on the species' breeding habitat. We also explain how the pattern of occurrence of the species in North Dakota compares to the general pattern throughout the rest of the northern prairie and parkland region.

Methods

Records of ibis occurrences in North Dakota were summarized from published reports, including those in *American Birds*, *Audubon Field Notes*, *National Audubon Society Field Notes*, and *North American Birds*, and unpublished reports filed with the North Dakota Birding Society (REM, unpublished data). We included data from the North American Breeding Bird Survey (BBS; 1966-2002; Sauer et al. 2005*), the National Audubon Society's Christmas Bird Count (NAS 2007*), and banding records from the U.S. Geological Survey Bird Banding Laboratory (USGS 2007*).

We defined a record as a museum specimen or a reported occurrence of an individual, group of individuals, or a colony. Records were summarized by date (year, month, and day if known) and location (to county level at a minimum). Nest records were defined as the presence of nests, eggs, dependent young, or adults exhibiting breeding behavior (e.g., carrying nesting material). Observations from 15 May to 31 August were considered breeding-season records, and observations from 1 September to 14 May were considered nonbreeding-season records, based on authors' observations of ibis behavior and phenological information as described by Ryder and Manry (1994). Occurrences of ibises at the same location over a range of days to months were counted as a single observation for purposes of annual summaries. To summarize data for the breeding and nonbreeding seasons, reports of the species at the same location within both seasons were counted as separate records, unless information indicated that individuals had nested at the location and were still present during the nonbreeding season.

We summarized information on use of wetlands for nesting from one published nest record and from three studies that measured habitat attributes of nesting ibis in North Dakota. Schmidt (1980a) provided a brief description of the habitat attributes of a wetland that supported several flightless young in 1978 and of one nest in southern North Dakota in 1979. During June and July 2000, Brice (2003) documented a multi-species colony that included ibis nests at Lake Alice National Wildlife Refuge (NWR; 48°19'54"N, 99°06'38"W), western Ramsey County, in northeastern North Dakota. Colony size was defined as the area occupied by nests of all colonially nesting species within the colony boundary, not just by ibis nests. Within the colony boundary, number of ibis nests, dominant vegetation, and presence of other bird species nesting within the colony were recorded. Two transects were placed lengthwise through the colony. The percent of water surface that was not covered or obstructed by standing or horizontal residual vegetation (i.e., percent open water), residual stem density, and water depth were measured within 86 1-m^2 sampling frames placed at 10-m intervals along the two transects (Table 1). Percent open water within the colony was recorded by visual estimation. Water depth was recorded using an approximately 3-cm diameter closet rod marked in 1-dm intervals. In 2001, this same colony was monitored for the presence of breeding ibises by USFWS personnel (Phelps and Meeks 2001*). Percentages of colony area composed of residual emergent vegetation and open water were visually estimated. During June and July 2001 and 2002, the USFWS (2001*, 2002*) documented ibis nesting activity on USFWS lands in Burleigh, Emmons, and Kidder counties in south-central North Dakota. The number of nests, the number of colonies, the dominant vegetation within colonies, and the presence of other nesting bird species were recorded on one NWR and one waterfowl production area (WPA). The ratio of live-to-residual emergent vegetation within colonies was visually estimated. In 2001, water depth at nests was measured using a meter stick. During June 2003, Knutsen (2004*) conducted a colonial-nesting waterbird inventory on 183 wetlands located on NWRs and WPAs in the Long Lake Wetland Management District (Knutsen 2004*). Wetlands were divided into three strata (high, moderate, and low) related to their likelihood of supporting a waterbird colony, based on habitat conditions in 2003, as well as the size and permanence of the wetlands (*sensu* Stewart and Kantrud 1971). Number of nests, number of colonies, dominant vegetation, and the presence of other colonial bird species nesting within colonies were recorded. The ratio of live-to-residual emergent vegetation within colonies and the percent of the colony's area that was composed of residual emergent vegetation and open water were visually estimated. Water depth was not measured in 2003. Vegetation density was classified into one of three categories: dense (heavy, thick stands of emergent vegetation with few visible openings), moderate (contiguous stands of emergent vegetation with numerous small openings), or sparse (large "canoe-sized" openings within the emergent vegetation of open-water floating mat colonies).

TABLE 1. White-faced Ibis colonies in North Dakota for which wetland and colony sizes, vegetation characteristics, and water depths were recorded.

Colony location	Year	Wetland size (ha)	Colony area (ha)[1]	Number of ibis nests or pairs	Dominant vegetation	% open water	% emergent vegetation	Ratio of live-to-dead vegetation	Water depth (cm)	Other species present	Source
Long Lake NWR, Burleigh Co	1978	6932[2]		2-4 nests in 1 colony	*Scirpus* sp.					Yes	Schmidt (1980a)
	2001	325	0.1-1.2	23 nests in 4 colonies	*Typha* spp., *Schoenoplectus* sp.			1:1 at 1 colony, more live than dead at 3 colonies	57-77	Yes	USFWS (2001*)
	2003	325	3.2	7 nests in 1 colony	*Typha* spp.					Yes	Knutsen (2004*)
Krafft Slough, Sargent Co.	1979	380		1 nest	*Typha* sp.				80	Yes	Schmidt (1980a)
Lake Alice NWR, Ramsey Co.	2000	4913	11	8 nests	*Typha* spp.	73			80	Yes	Brice (2003)
	2001	4913	10-27	31 pairs in 3 colonies	*Typha* spp.	20-50	30-50			Yes	Phelps and Meeks (2001*)
Kleppe Lang WPA (Dewald Slough), Kidder Co.	2002	345	2.8, 6.0	11 nests in 2 colonies	*Phragmites australis*, *Typha* spp., *Schoenoplectus* sp.			1:1 at the smaller colony, more live than dead at larger colony		Yes	USFWS (2002*)
	2003	345	6.5	8 nests in 1 colony	*Phragmites australis*, *Typha* spp., *Schoenoplectus* sp.	15	85	9:1		Yes	Knutsen (2004*)

[1]Colony area refers to the area occupied, by nests of all colonially nesting species within the colony, not just to ibis nests.
[2]The wetland size for the 1978 ibis observation includes the entire wetland basin size for Long Lake. The wetland size in 2001 and 2003 reflects the size of an impoundment that did not exist in 1978.

Results

Ibis in North Dakota

The only reported observation of ibis in North Dakota in the nineteenth century was of a specimen that was collected in 1882 and deposited in the University of Michigan's Museum of Zoology (Wood 1923). Wood (1923) also reported the first two occurrences in the twentieth century, including single individuals in Morton County in 1912 and in Slope County in May 1920. The fourth report of an ibis occurred over 40 years later, on 5 June 1961, in Stutsman County (*fide* REM). This observation marked the beginning of the species' documented range expansion into North Dakota (Figure 1). Observations of ibis increased markedly between the 1960s and 1990s. Between 1961 and 2002, the species has been observed nearly annually, occurring in all but nine of the 42 years.

From 1882 to 2002, there were 145 reports of one or more White-faced Ibis in North Dakota, including 93 reports during the breeding season, 49 during the nonbreeding season, and three for which the season of occurrence was not reported. Of the 107 occurrences of the species during the twentieth century, 71 occurred during the breeding season, 34 during the nonbreeding season, and the season of occurrence for two early records was unknown (Figure 1). During the twentieth century, no occurrences were reported from January through March, and two occurrences each were reported in November and December (Figure 2). The earliest observation within a year was 14 April, which occurred in 2002 at Long Lake NWR (46°43'59"N, 100°05'43"W) in Burleigh County (P. C. Van Ningen, U.S. Fish and Wildlife Service, Moffit, North Dakota, personal communication). The latest observation within a year was 17 December 1999 in Sargent County (D. Kinzler, Oakes, North Dakota, personal communication). The largest group of birds observed during the breeding season was about 400 individuals on 11 August 2001 in Sargent County; this group was undoubtedly a post-breeding flock (Martin 2002). The largest group of birds observed during the nonbreeding season was over 50 individuals in September 2000 in Kidder County by H. F. Duebbert (Martin 2001).

From 1912 to 2002, ibises have been sighted in 28 (53%) of the 53 counties in North Dakota (Figure 3). Observations first occurred west of the Missouri River. The two observations in the early part of the twentieth century both occurred in the western part of the state (Wood 1923). Of the eight occurrences in the 1960s, all were reported from southern counties, but only one occurred west of the Missouri River, in Slope County (G. B. Berkey, personal communication). Most observations after the 1960s were east and north of the Missouri River. The first occurrences in the northern half of the state occurred in 1973 at Upper Souris NWR (48°30'11"N, 101°31'50"W), Renville County, by I. O. Rostad (Houston 1974) and in 1974 at J. Clark Salyer NWR (48°40'52"N, 100°47'23"W), McHenry County,

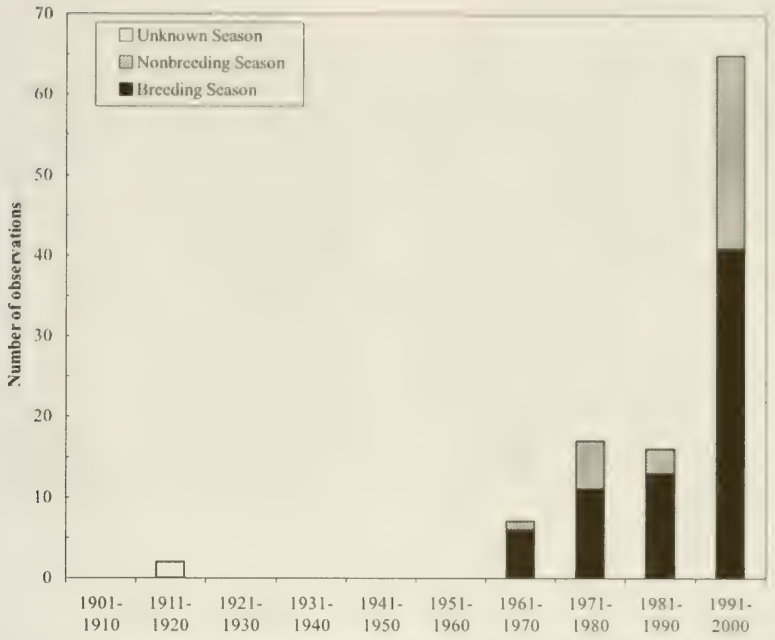

FIGURE 1. Records of White-faced Ibis occurrences in North Dakota during the twentieth century, by decade.

by R. C. Fields (Houston and Houston 1974). The first sightings in five counties (Bottineau, Foster, Mercer, Pierce, and Ward) occurred recently, within 2001-2002.

To date, there are 21 records of nesting activity in North Dakota (Table 2). The first nest was reported by R. A. Schmidt and R. N. Randall in 1978 (Serr 1978; Schmidt 1980a). From 1978 to 2003, nests have been reported in ten of the 26 years, with the majority occurring between 2000 and 2003. Nests or nesting activity have been reported in each of the four recent years from 2000 to 2003. The number of nests discovered within an individual wetland varied from one to 31. All 21 nesting observations were recorded in June, July, or August. Observations in June indicated that nesting had been initiated in May. By August, young or fledglings were observed. Nesting ibises have been observed in eight of the 53 counties (Table 2, Figure 3). Most nesting activity was recorded in Burleigh and Kidder counties (Table 2). Of the ten known wetlands that have contained nesting ibises, six are federally owned; two involve a mixture of federal, state, and/or private ownerships; and two are privately owned.

The ibis has been recorded on a Breeding Bird Survey route in North Dakota in only one year since the survey's inception in 1966. On 10 June 1999, three individual ibis were reported by H. C. Talkington (Mandan, North Dakota, personal communication) on his BBS route south of Tappen in Kidder County. According to banding records, three flightless young were banded in late July 1979, in western Sargent County (K. Klimkiewicz, U.S. Geological Survey, Laurel, Maryland, personal communication). No ibises have been recorded in North Dakota on a Christmas Bird Count, which have been conducted in the state since the early 1900s.

In North Dakota, ibises have been found breeding only in large (>300 ha) semipermanent or permanent wetlands. Colonies, all of which were mixed-species colonies, were located in patches of emergent vegetation dominated by cattails and bulrushes and ranged in areal extent from 0.1 to 27 ha (Table 1). Ibises appeared to prefer a fairly equal proportion of open water and emergent vegetation within a wetland basin, with half or more of the vegetation composed of live rather than residual stems. Water depths varied from 60 to 80 cm. Schmidt (1980a) reported that one ibis nest was built just above the water level in residual cattails interspersed with open water and was located 600 m from shore and 20 m from the central open water area of the wetland basin. Flightless ibises were located in emergent vegetation about 700 m from shore and 35 m from open water. Brice (2003) reported that the mean density of residual cattail stems within an ibis colony was 44 stems/m^2. Knutsen (2004*) found that two of 40 waterbird colonies contained ibis nests. Both of these ibis colonies were located on wetlands categorized as having a high probability of supporting a waterbird colony. One of the colonies was located on an impoundment of Long Lake that contained ibises in 2001, and the other was located on a WPA that contained

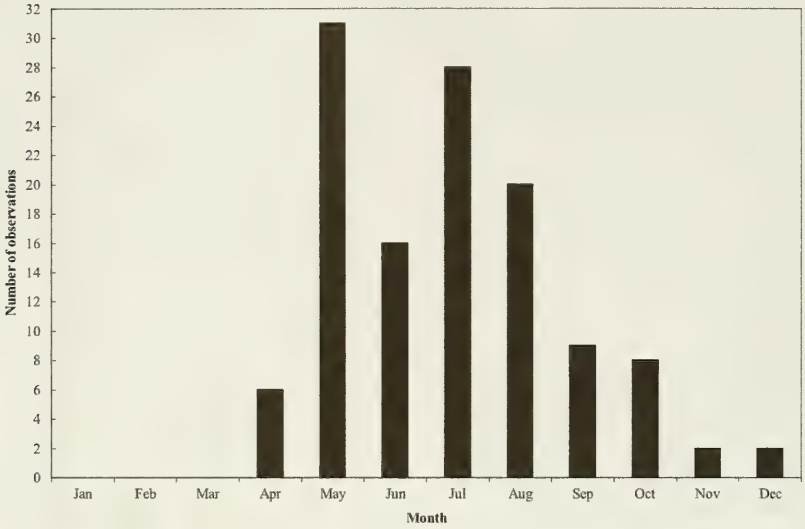

FIGURE 2. Records of White-faced Ibis occurrences in North Dakota during the twentieth century, by month. An observation was counted once, regardless of whether the observation was of one or of multiple individuals.

ibises in 2002 (Table 1). Vegetation density within the colony in the impoundment was categorized as moderate, whereas vegetation density within the colony in the WPA was categorized as dense. Several other waterbird species occurred at colonies with ibises (Table 1). These species included Ruddy Duck (*Oxyura jamaicensis*), Horned Grebe (*Podiceps auritus*), Eared Grebe (*Podiceps nigricollis*), Western Grebe (*Aechmophorus occidentalis*), Clark's Grebe (*Aechmophorus clarkii*), Snowy Egret (*Egretta thula*), Cattle Egret (*Bubulcus ibis*), Black-crowned Night-Heron (*Nycticorax nycticorax*), American Coot (*Fulica americana*), Franklin's Gull (*Larus pipixcan*), Forster's Tern (*Sterna forsteri*), and Black Tern (*Chlidonias niger*) (Schmidt 1980a; Phelps and Meeks 2001*; USFWS 2001*, 2002*; Brice 2003; Knutsen 2004*).

Ibis expansion in the northern prairie and parkland region

There appears to be a consistent pattern throughout the northern prairie and parkland region concerning the chronological progression from the first occurrences to the establishment of breeding colonies (Table 3). From our examination of regional patterns of ibis distribution, we determined that the species rarely visited the northern prairie and parkland region in the late nineteenth and early twentieth centuries and did not develop breeding populations until the late twentieth century. North Dakota, Iowa, and Minnesota reported ibis occurrences as early as the late nineteenth century (Peabody 1896; Lokemoen 1979; Schmidt 1980a; Janssen 1987; Kent and Dinsmore 1996), and Nebraska and Alberta reported occurrences during the early twentieth century (Kondla et al. 1973; Goossen et al. 1995; Mollhoff 2001). Montana, South Dakota, Manitoba, and Saskatchewan did not report ibis occurrences until the mid-to-late twentieth century (Skaar 1969; Serr 1975; DuBois 1989; Goossen et al. 1995; Tallman et al. 2002). The first nests in the region were reported in 1894 in Minnesota (Peabody 1896) and in 1916 in Nebraska (Mollhoff 2001), but other states and provinces did not report nesting ibis until the mid-to-late twentieth century. Two nest records have been reported for Saskatchewan, both of which occurred in 2000 (B. Hepworth, Ducks Unlimited Canada, Regina, Saskatchewan, personal communication; P. Taylor, Canadian Wildlife Service, Environment Canada, Saskatoon, Saskatchewan, personal communication). Bazin and Artuso (2006) documented the first nest record for Manitoba in 2005. Jorgenson and Dinsmore (2005) summarized recent nesting records for Alberta and some of the states in the northern prairie and parkland region. An additional nest record in Alberta was reported by Flockhart (2001).

Discussion

The number of occurrences of ibises in North Dakota reached the point that the North Dakota Birding Society stopped recording new nonbreeding observations after about 2002 (REM, unpublished data). Nesting ibises are becoming increasingly common, with multiple reports of nests every year from 2000 to 2003 (Table 2). Spring arrival in North Dakota typically begins in mid-to-late April, and birds begin departing in September (Figure 2). Few birds remain in the state in November and December, and no records exist for January through March. Nesting occurs from mid-May to late August (Table 2). The ibis appears to nest colonially with other waterbird species as has been report-

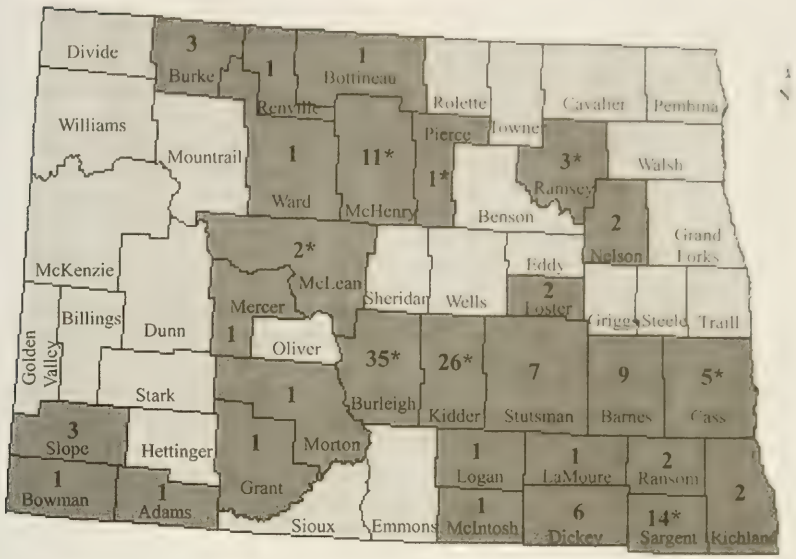

FIGURE 3. Records of White-faced Ibis occurrences in North Dakota during the twentieth century and 2001-2002, by county. Asterisks (*) denote counties in which nesting activity has been observed during the twentieth century and 2001-2003.

ed by other researchers in the northern prairie and parkland region (Peabody 1896; Dinsmore and Dinsmore 1986; Mollhoff 2001). Based on our findings, we believe that the status of ibis in North Dakota is that of a fairly common migrant and a locally uncommon breeder east of the Missouri River and a casual migrant west of the Missouri River.

Of the ten known wetlands that have contained nesting ibis, most are under federal management. These wetlands are protected from drainage and tillage; therefore, thick stands of cattails and other tall wetland vegetation are able to become established in some years (Table 1). These wetlands also may experience higher levels of human visitation than privately owned wetlands. More human visits, either by federal employees conducting biological surveys or by bird watchers and nature enthusiasts visiting the NWRs, WPAs, and other federal properties, could explain the greater number of reports of nesting activity on federally managed properties.

Because ibises were present as vagrants in some parts of the northern prairie and parkland region in the late nineteenth century, several authors have speculated that the presence of breeding colonies in the twentieth century was not so much an expansion of the species' range as it was the reclamation of portions of the species' former range (Ryder and Manry 1994; Dinsmore et al. 1984). Goossen et al. (1995) advanced several explanations for the expansion of breeding ibises into Canada, which included population growth; loss of habitat to draining, flooding, or drought in other portions of the species' breeding range; dispersal; and an increase in suitable habitat due to the advent of managed or restored wetlands and irrigation. The virtual absence of sightings from the late nineteenth century through the early twentieth century in the northern prairie and parkland region (Table 3) coincided with the withdrawal of ibises from inland areas in Texas, suggesting to Jorgenson and Dinsmore (2005) that sightings in northern regions in the late nineteenth century and first half of the twentieth century were linked to fluctuations in the Gulf Coast populations. They examined the historical status of the species from Alberta to Texas and suggested that the current range expansion appears to be unprecedented. They contended that the idea that ibises occupied the northern Great Plains in the nineteenth century was based on only three nesting records that occurred at a time when extralimital breeding of the species was being documented elsewhere in the continent. They suggested that the development of breeding populations of ibises was linked to population fluctuations in the species' core breeding areas of Texas, Louisiana, and, more likely in modern times, to fluctuations occurring in the Intermountain West, the region of North America lying between the Rocky Mountains to the east and the Cascades and Sierra Nevada to the west.

Drawing upon knowledge of habitat, climate, and socioeconomic conditions in the northern Great Plains, using North Dakota as an example, we suggest further explanations for the pattern of ibis observations. Those explanations include habitat perturbations and habitat loss in other parts of the ibis' range, climate and precipitation patterns in the northern prairie and parkland region that impacted habitat conditions, and socioeconomic conditions. We concur with Jorgenson

TABLE 2. Nesting records of White-faced Ibis in North Dakota through 2003.[1]

Date(s)	Location	Number of adults or pairs, young, or nests	Observer(s)	Source
18-30 July 1978	Long Lake National Wildlife Refuge (NWR), Burleigh Co. 46°43'59"N, 100°05'43"W	10 adults, 2 nests	R. A. Schmidt, R. N. Randall	Serr 1978, Schmidt 1980a
5 June – 12 August 1979	Kraft Slough, Sargent Co. 46°07'53"N, 97°55'37"W	1 pair, 4 fledglings	R. A. Schmidt	Serr (1979), Schmidt (1980a)
1 June 1982	Lake Nettie NWR, McLean Co. 47°37'29"N, 101°00'14"W	5 adults, 2 nests with eggs	Audubon NWR staff	North Dakota Birding Society, unpublished data
July 1988	Kleppe Lang Waterfowl Production Area (WPA; also known as DeWald Slough), Kidder Co. 46°47'36"N, 99°46'36"W	1 nest	M. W. Goos	Berkey (1988)
13 July 1988	Stoney Slough, Burleigh Co. 46°53'29"N, 100°05'37"W	1 nest	M. W. Goos	Berkey (1988)
15 July 1988	North Dakota WPA, Burleigh Co. 47°04'46"N, 100°07'51"W	2 nests with eggs	M. W. Goos	Berkey (1988)
18 July 1990	J. Clark Salyer NWR, McHenry Co. 48°40'52"N, 100°47'23"W	1 nest with 2 eggs, 2 young	B. Berg	North Dakota Birding Society, unpublished data
25 July – 11 August 1990	Kleppe Lang WPA	2 adults, 1 nest with 3 eggs	C. Klindtworth	North Dakota Birding Society, unpublished data
July 1996	Kleppe Lang WPA	Several nests	B. A. Sova	North Dakota Birding Society, unpublished data
June 2000	Lake Alice NWR, Ramsey Co. 48°19'54"N, 99°06'38"W	8 nests	J. S. Brice	Brice (2003), Svingen and Martin (2003)
July 2000	Long Lake NWR	Several nests	K. L. Lang	North Dakota Birding Society, unpublished data
June 2001	Kleppe Lang WPA	4 to 6 pairs	R. E. Martin	this paper
June 2001	Lake Alice NWR	31 nests	W. A. Meeks	Phelps and Meeks (2001*)
22 June 2001	Long Lake NWR	Numerous adults and fledglings, 23 nests	G. A. Knutsen	USFWS (2001*)
late July 2002	Alice WPA (also known as Lake Bertha), Cass Co. 46°45'47"N, 97°30'35"W	4 adults, 1 nest with 3 eggs	R. H. O'Connor, R. Gjervold	North Dakota Birding Society, unpublished data
2 July 2002	Kleppe Lang WPA	11 nests	G. A. Knutsen	USFWS (2002*)
June 2003	Kleppe Lang WPA	8 nests	G. A. Knutsen	Knutsen (2004*)
June 2003	Long Lake NWR	7 nests	G. A. Knutsen	Knutsen (2004*)
22 July 2003	J. Clark Salyer NWR	21 pairs	R. E. Martin	this paper
26 July 2003	Lake Alice NWR	10 pairs	R. E. Martin	this paper
18 August 2003	Unnamed wetland in southern Pierce Co. 47°56'55"N, 100°01'19"W	10 adults, including adults feeding young in nest	R. E. Martin	Martin (2004)

[1] Beyond 2003, U.S. Fish and Wildlife Service personnel no longer quantified colony and nest numbers on NWRs and WPAs.

and Dinsmore's (2005) suggestion that ibis occurrences in the northern Great Plains during the late nineteenth century and early twentieth century may have been due to extralimital wandering as was occurring in other parts of the U.S. at the same time, combined with the species' predilection for post-breeding dispersal north of its nesting grounds (Ryder 1967; Ryder and Manry 1994).

No ibises were reported in North Dakota between 1920 and 1961 (Table 3). Plausible explanations include a scarcity of suitable nesting habitat and a low level of human engagement in nature-based activities. Potential suitable wetland habitat for ibises deteriorated with the onset of drought that characterized the 1930s, the Dust Bowl years (Robinson 1966). Given the duration and intensity of that drought, it is highly likely that suitable wetland habitat was largely nonexistent in the 1930s.

The widespread drought of the 1930s, combined with economic collapse during the Great Depression, resulted in a human exodus from North Dakota (Robinson 1966). The human population in North Dakota reached the highest levels to date, according to the 1930 census, and experienced a 9% decline between 1930 and 1950 (USCB 2005), with much of the decline occurring in rural areas. The human population continues to fluctuate and recovered somewhat from the 1950s, but never has reached the levels experienced prior to the 1930s. During the 1940s, fewer people lived in North Dakota than in the 1920s or 1930s (Kazeck 1956), and some people that remained were called to war or were engaged in war-related activities. During the war, ammunition was rationed and hunting activities were subsequently curtailed. Overall, then, there likely were fewer people afield and thus there were fewer chances of people encountering ibises during this time.

Also during the 1940s, moisture conditions, and thus potential ibis habitat, began to improve, with the highest annual precipitation at Bismarck between 1900 and 2000 occurring in 1941 with 79.1 cm (NCDC 2004*). Concomitant with improved moisture conditions was the invasion into North Dakota of an introduced species of European cattail, the Narrowleaf Cattail (*Typha angustifolia*), which was first collected in North Dakota in 1942 at Long Lake NWR (Kantrud 1992). Prior to that time, there were few cattail-dominated wetlands in North Dakota, and the few stands that did exist were in boggy areas around freshwater lakes (Kantrud 1992). Narrowleaf Cattail was restricted largely to the southeastern portion of North Dakota in the early 1960s and spread to many wetlands in central North Dakota by the 1970s (Kantrud 1992). However, the invasive species hybridized with the native Broadleaf Cattail (*Typha latifolia*), and the resulting hybrid (*Typha* ×*glauca*) spread rapidly throughout the prairie pothole region of North Dakota during the 1950s, becoming the most abundant large hydrophyte in the state (Kantrud 1992). Wetlands dominated by the hybrid cattail potentially provided prime breeding habitat for ibises. Also, despite the decrease in the number

TABLE 3. Pattern for the northern prairie and parkland region, USA and Canada, that exhibits the lapse between time of first White-faced Ibis observations, time of consistent (>5 observations in a given decade) observations, and year of first nest record.

	Early sightings			Consistent sightings				
	Late 1800s	Early 1900s	Mid-to-late 1900s	Late 1800s	Early 1900s	Mid-to-late 1900s	First nest	Sources
North Dakota	1882	1912				1960s	1978	Lokemoen 1979; Schmidt 1980*a*; this paper
Iowa	1891					1980s	1986	Dinsmore and Dinsmore 1986; Kent and Dinsmore 1996
Minnesota	1894-1895	1910				1960s	1894	Peabody 1896; Janssen 1987
Nebraska		1916	1983-1984				1916	Mollhoff 2001
Montana			1950			1960s	1970	Skaar 1969; DuBois 1989
South Dakota			1962			1970s	1978	SDOU 1991; Tallman et al. 2002
Alberta		1941	1964			1970s	1982	Kondla et al. 1973; Goossen et al. 1995
Manitoba			1975				2005	Serr 1975; Goossen et al. 1995; Bazin and Artuso 2006
Saskatchewan			1976			1970s	2000	Goossen et al. 1995; personal communications: B. Hepworth[1]; R. Luterbach[2]; P. Taylor[3].

[1]B. Hepworth, Ducks Unlimited Canada, Regina, Saskatchewan, personal communication. [2]R. Luterbach, Regina, Saskatchewan, personal communication [3]P. Taylor, Canadian Wildlife Service, Saskatoon, Saskatchewan, personal communication.

of temporarily flooded wetlands due to drainage, the number of permanent wetlands in the form of basin wetlands and riverine impoundments increased in the state (Lokemoen 1979).

Kantrud (1992) suggested that prairie wildfires and grazing by large ungulates, two major ecological forces during presettlement times, were responsible for the restricted distribution of Broadleaf Cattail prior to the invasion of Narrowleaf Cattail. Many semipermanent wetlands in eastern North Dakota, eastern South Dakota, and western Minnesota that were grazed and that were dominated by semi-open stands of Hardstem Bulrush (*Schoenoplectus acutus*) presently are not grazed and are dominated by dense stands of cattail. Gary Krapu (U.S. Geological Survey, Jamestown, North Dakota, personal communication) recalls that, prior to the mid-1950s in North Dakota, most wetlands experienced grazing pressure by livestock or were hayed. In the late 1950s and 1960s, however, many farmers began to focus exclusively on small-grain production, phasing out livestock production. Livestock were beneficial in stopping the growth of dense stands of cattails by eating young, green cattail shoots. With the loss of grazing pressure, Narrowleaf Cattail more easily became established in wetlands. The decline in farm operations that raised livestock was hastened by the Soil Bank Program in the 1950s, which provided farmers with annual payments under 5-to-10 year contracts to idle their cropland by planting to perennial cover. This program indirectly also encouraged the idling of wetlands as farmers reduced the number of livestock that they produced.

During the 1950s and 1960s in southern portions of the species' breeding range, ibis breeding habitat was being lost due to human encroachment or drought. Breeding colonies of ibises disappeared or decreased in size due to habitat loss or pesticide contamination in Oregon, California, and Nevada (Ryder 1967; Ryder and Manry 1994). This decline coincided with increased sightings in Minnesota, North Dakota, South Dakota, and Montana (Table 3). It is plausible that this highly nomadic species sought and found better breeding conditions in the northern prairie and parkland region than in its more traditional breeding range.

Banding studies during the 1960s found that shooting was the major cause of reported deaths for this species, with many bands recovered from Mexico (DuBois 1989). The species was a gamebird until the early twentieth century, when international treaties conferred protection from hunting or harassment. Lokemoen (1979) postulated that ibis population increases might have been due in part to federal protection. Although federal protection of migratory birds began in 1918 with the signing of the Migratory Bird Treaty (Legal Information Institute 2005*), resources were not available for widespread federal enforcement in North Dakota until the 1940s (G. Krapu, personal communication).

After the late 1960s, pesticide contamination and continued habitat loss occurred in southern states, coinciding with more frequent ibis sightings and first nest records in several northern states. King et al. (1980) monitored eggshell thickness, pollutant residues, and the population status of the species in Texas from 1969 through 1976. They found that nesting populations declined by 42%, associated with low reproductive success caused by DDE-induced shell thinning and dieldrin mortality. Taylor et al. (1989) reported that the ibis population doubled in the late 1970s in Utah and also increased in Oregon. They attributed these increases to flooding in the Great Basin during the early 1980s, recovery from reduced productivity caused by DDT in the 1970s, and/or natural fluctuations in ibis populations.

Other Ciconiiformes species also increased in occurrences and expanded their distribution during the same time period in North Dakota and other areas of the northern prairie and parkland region (Jones and Malcolm 1978; Lokemoen 1979; Schmidt 1979a,b, 1980b; Lambeth 1980). The first Cattle Egret in North Dakota was reported in 1971 (Lokemoen 1979), and the first nesting colony was discovered in 1976 among nests of Black-crowned Night-Herons and Little Blue Herons (*Egretta caerulea*) (Jones and Malcolm 1978). More Cattle Egret colonies were discovered in the ensuing years (Schmidt 1980b). It is possible that the presence of the colonies of Cattle Egret and other colonial-nesting birds provided the stimulus that prompted ibis to establish colonies.

More recently, the increase in White-faced Ibis observations in North Dakota has coincided with the wet conditions experienced in the northern prairie and parkland region from 1993 to the present (NCDC 2004*). The current wet cycle may be the wettest period during the past 130 years (Winter and Rosenberry 1998). These wet conditions may be contributing to suitable habitat conditions for the ibis. Johnson (1994) documented large-scale pioneering expansion of nesting distributions of several species of western North American birds over the last three decades. Although Johnson (1994) did invoke climatic warming as a possible explanation, he believed that it was neither the sole explanation nor even the primary cause. Rather, he hypothesized that many of the species were responding to a decades-long increase in summer rainfall in regions beyond their former ranges, based on regional climatic trends. Summer moisture, perhaps coupled with a higher mean temperature, encouraged avian range expansions. Detailed correlations of local climatic data with temperature and moisture requirements of individual species would be necessary to establish causality (Johnson 1994).

We believe that the combination of adequate rainfall and invasion of Narrowleaf Cattail in the 1940s in North Dakota, the rapid establishment of Narrowleaf Cattail and its hybridization with the Broadleaf Cat-

tail during the ensuing decades, the general expansion of other ciconiiform species, the conversion from ranching to small-grain production, wetland loss and poor ibis reproduction in the southern portions of the ibis breeding range, growing ibis populations in the Intermountain West region, wet conditions suitable for colonial waterbird establishment, and climatic changes have contributed to the growth of ibis populations in North Dakota. We suspect that the above factors also may have played a role in population changes elsewhere in the northern prairie and parkland region. Ibises are considered rare, localized breeders in the northern prairie and parkland region (Beyersbergen et al. 2004) and, more specifically, are considered locally uncommon in North Dakota (this paper), rare to locally uncommon in South Dakota (Sabo 1992), and a rare summer resident in Canada (Goossen et al. 1995).

The future status of ibis within the northern prairie and parkland region likely will depend upon precipitation patterns. With continuing years of adequate rainfall, wetlands that harbored colonies should continue to provide suitable habitat. There are no indications that the spread of monotypic stands of cattail within wetlands will abate, which should only aid in the spread of ibis into new breeding areas. Already, breeding sites in North Dakota that once contained only a few birds and nests now contain larger groups of nesting birds. With an onset of a prolonged drought, the quality of nesting habitat could decline in some wetlands, but water levels in other wetlands that had been inundated to the degree that they no longer supported emergent vegetation would recede and again allow the growth of deep-marsh vegetation that could harbor new nesting colonies. Even in a prolonged drought, colonies could persist at managed wetlands, such as those maintained within certain NWRs. From these colonies, ibis could disperse when precipitation levels again rise at previously dry wetlands.

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Recent Distribution Records of the Little Brown Bat, *Myotis lucifugus*, in Manitoba and Northwestern Ontario

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Until recently, the distribution of the Little Brown Bat (*Myotis lucifugus*) in Manitoba and northwestern Ontario was poorly documented. Since 1988, we have been banding and recapturing little browns throughout Manitoba and adjacent Lake of the Woods region in Ontario. All known hibernacula in the study area are recorded here for the first time, along with time of emergence. Connections between some hibernacula and summer nurseries are verified by band returns, ranging from 37 to 540 km.

Key Words: Little Brown Bat, *Myotis lucifugus*, distribution, Manitoba, northwestern Ontario.

We began our study of the Little Brown Bat *(Myotis lucifugus)* in 1988. The objectives of the study were: (1) to map the distribution of Little Brown Bats in Manitoba; (2) to find as many hibernacula and summer nursery roosts as possible; (3) to learn where bats found in hibernacula spend the summer; and (4) where bats found in summer roosts spend the winter. An overriding objective has been to encourage awareness and conservation of bats among the public and responsible agencies in Manitoba. All work was done under Manitoba Conservation "Wildlife Scientific Research", "Ecological Reserves Research", and Ontario Ministry of Natural Resources (Kenora District) permits issued to Dubois.

Little previous research had been done on the six species of bats known to occur in Manitoba (Banfield 1974). Robert Barclay worked on some species and made incidental observations of occurrences and migration dates of little browns at the University of Manitoba Delta Marsh Field Station from 1981 to 1983 (Barclay 1984). Barclay (1993) stressed "Even for species that are well studied elsewhere, such as the Little Brown Bat, information about the biology of prairie populations is scarce. More than anything else, it is this lack of information that hinders conservation efforts for prairie bats." This study is meant to aid conservation efforts by filling gaps in our knowledge.

A. L. Rand (1948) reported sightings of the Little Brown Bat in the Flin Flon district. J. Dewey Soper (1961) reported the first specimens taken at Max Lake, in Turtle Mountain Provincial Park, 20 August 1949. Little browns were reported from the Delta area (Tamsitt 1962). In 1978 the late Walter Cook of Grand Rapids showed provincial biologist Bill Koonz a couple of caves north of the town that over-wintered bats (Koonz, Manitoba Conservation, personal communication). Since 1988 systematic searching for caves with the Speleological Society of Manitoba (SSM) has produced more information on the Little Brown Bat in Manitoba. Soliciting the public and various agencies to report caves, summer bat roosts and sightings has also been very productive.

Methods

We banded Little Brown Bats to monitor their distribution and seasonal movements. Plastic coloured bands were used in the first year of banding, 1988. Each cave or location was identified by a different colour. For more precise tracking of individual bats and their movements, numbered aluminium bands (National Band & Tag Co., Kentucky), size 2 were used in 1989 and thereafter.

Hibernacula were located with the aid of the considerable efforts of the members of the Speleological Society of Manitoba and other volunteers. Starting from reported hibernacula sites, the authors and other members of the SSM used a combination of surficial geology, topographic maps, and air photos to identify likely areas for methodical ground searches. Karst features such as caves, sinkholes and trenches were detected on air photos in areas where limestone, dolomite and gypsum bedrock are near the surface. These areas were then visited and searched in a grid pattern, using map and compass, and latterly, hand-held global positioning system (GPS) units.

Information provided by home and cottage owners, Manitoba Department of Conservation, Ontario Ministry of Natural Resources, and other agencies led to the banding of bats in residential and cottage summer nursery colonies throughout the province, spilling over into adjacent northwestern Ontario around the north end of Lake of the Woods.

Greatest frequency of banding occurred in caves in the Grand Rapids and Gypsumville areas, and in one large cave (St. George Cave) north of Hodgson. [See map, Figure 1] The karst features, where the caves are found in gypsum and dolomite formations of these areas, are

described in detail in the field reports of the Manitoba Mines Branch for 1988, 1989 and 1990 (e.g., Sweet et al. 1988) and in McRitchie and Monson (2000).

We used standard techniques to capture and band the bats (Kunz and Kurta 1988). We captured them in caves by plucking the torpid bats carefully by hand from the cave wall, and placing them in a cloth bag. We live-trapped Little Brown Bats with a harp trap (Tuttle 1974). Once captured, the bats were examined to determine sex, reproductive status, age, injuries (both healed and fresh), and, on a cursory basis, external parasites present. According to custom (Kunz and Kurta

TABLE 1. Hibernacula banding locations in Manitoba and northwestern Ontario for Little Brown Bats.

Location	Latitude	Longitude
Cook's Cave [GR]	53°26'10"N	99°32'10"W
Dale's Cave [GR]	53°39'32"N	99°26'19"W
Firecamp Cave [GR]	53°29'25"N	99°20'50"W
Fold Cavern [Gyp]	51°51'02"N	98°29'30"W
Iguana Crypt [GR]	53°26'14"N	99°30'58"W
Longcrawl Cave [Gyp]	51°47'10"N	98°37'00"W
Microwave Cave [GR]	53°34'05"N	99°26'25"W
Squeaky Cave [GR]	53°37'42"N	99°20'31"W
St. George Cave [Hod]	51°36'07"N	97°24'52"W
Stormcloud Cave [Gyp]	51°50'28"N	98°29'40"W
Richard Lake, Ont. [LW]	49°50'54"N	94°41'30"W
Abyss Cave [GR]	53°42'55"N	99°25'40"W
Okaw Cave [GR]	53°51'53"N	100°07'12"W

[GR] = Grand Rapids area; [Gyp] = Gypsumville area; [Hod] = Hodgson area; [Wh] = Whiteshell area; [LW] = Lake of the Woods

TABLE 2. Summer nursery colony banding locations in Manitoba and northwestern Ontario for Little Brown Bats.

Location	Latitude	Longitude
Brereton Lake, Manitoba	49°54'16"N	95°32'40"W
Caliper Lake Provincial Park, Ontario	49°03'42"N	93°54'46"W
Deleau, Manitoba	49°34'52"N	100°34'31"W
French Portage Narrows, Ontario	49°26'58"N	94°40'14"W
Grand Rapids, Manitoba	53°12'30"N	99°18'00"W
Jackfish Lake, Manitoba	50°18'05"N	100°02'10"W
Keewatin, Ontario	49°45'33"N	94°33'20"W
Melita, Manitoba	49°16'05"N	100°59'45"W
Moosehorn, Manitoba	51°17'29"N	98°25'22"W
Pebble Beach, Manitoba	50°59'34"N	98°26'53"W
Rush Bay, Lake of the Woods, Ontario	49°39'55"N	94°53'28"W
Rushing River Provincial Park, Ontario	49°41'13"N	94°13'44"W
Schist Lake, Manitoba	54°39'45"N	101°48'19"W
Sherridon, Manitoba	55°07'26"N	101°05'12"W
Wasagaming, Manitoba	50°39'30"N	99°58'07"W
Wekusko Falls, Manitoba	54°47'22"N	99°58'21"W

TABLE 3. Additional Little Brown Bat locations in Manitoba and northwestern Ontario verified by the authors.

Location	Latitude	Longitude
Souris, Manitoba	49°37'02"N	100°15'37"W
Reston, Manitoba	49°33'27"N	101°05'36"W
Minnedosa, Manitoba	50°14'43"N	99°50'34"W
Falcon Lake, Manitoba	49°41'11"N	95°14'54"W
Deception Lake, Ontario	49°44'27"N	94°50'33"W
Setting Lake, Manitoba	55°04'11"N	98°29'46"W
Woodridge, Manitoba	49°17'02"N	96°08'52"W
vicinity of Oak Lake, Manitoba	49°40'17"N	100°37'34"W
Kerr's Lake, Manitoba	50°30'00"N	99°40'57"W
Pointe du Bois, Manitoba	50°18'03"N	95°33'05"W
Otter Falls, Manitoba	50°08'48"N	95°48'38"W
Taiga Biological Station, Wallace Lake, Manitoba	51°02'40"N	95°20'40"W
Winnipeg, Manitoba	49°53'04"N	97°08'47"W

FIGURE 1. Map of Manitoba showing the portion of the Boreal Ecozone and major settlements. Circles are settlements, triangles are other localities (see text).

1988), we banded males on the right forearm and females on the left. Those bats found to be previously banded were duly recorded and injuries and/or parasites noted. Time in capture and handling was kept to a minimum to avoid stressing the animals. Banding locations are summarized in Tables 1 and 2, below.

Many of the Manitoba caves containing bats were mapped, the annual maximum and minimum temperatures recorded (average +5°C) and any other vertebrate or invertebrate inhabitants noted, by us, other SSM members, and by staff of the Manitoba Museum and the Manitoba Geological Survey. These details and more on the caves and surrounding landscapes are thoroughly described in McRitchie and Monson (2000).

Results

To date we have banded more than 9000 Little Brown Bats. J. Dewey Soper (1961) speculated that Little Brown Bats "probably extend almost to the Hudsonian Zone", now called the Boreal Shield ecozone (Ecological Stratification Working Group 1995), while van Zyll de Jong (1985) stated: "It is found from the Atlantic to the Pacific coast and occurs to the limits of the boreal forest."

In addition to those locations where banding has taken place (Tables 1 and 2), we have verified the presence of this species throughout southern Manitoba and at least to the latitude of Taiga Biological Station, University of Manitoba, Wallace Lake (51°01'50"N), east of Lake Winnipeg (Table 3). On the west side of the province, Little Brown Bats occur to the latitude of Sherridon (55°07'26"N), and in north-central parts of the province to Setting Lake (55°04'11"N) (Table 3) – locations slightly north and just south of Herb Lake (reported in van Zyll de Jong 1985, page 70).

Similar to many species across Canada, a combination of degree-days and night-length likely constrains their range in the north – see discussions in Holroyd et al. (1994), Nagorsen and Brigham (1993), Humphries et al. (2002). A maternity roost of Little Brown Bats was reported recently at 58°06'36"N on the Alaskan coast (Parker and Cook 1996), as was one at Squanga Lake, Yukon at 60°28'40"N (Jung and Slough 2005) .

Sherridon (55°07'26"N) is the site of the northernmost nursery colony we have found in Manitoba to date, while Okaw Cave (53°51'53"N) is the northernmost hibernaculum. Individual Little Brown Bats have been reported during summers from as far north as Thompson (55°44'36"N). Little browns have been reported to us as showing up at summer nursery colonies in central and southern Manitoba as early as the last week in April, and more often, the first week of May. However, we routinely find large numbers of a given hibernaculum still in torpor when entering the caves in the Grand Rapids area on the Victoria Day long weekend in May (normally the third weekend of the month, range 17-28 May).

Band returns from this study have shown little browns are very loyal to both their summer and winter roosts, with very low incidences of transference (>1%). Recoveries from subsequent, different roosts ranged from 5 km to 533 km distant from point of original banding. Seasonal migration distance from hibernacula to summer nursery colony for adult females ranged from 37 km to 540 km. Details of inter-roost and seasonal movements will be published separately.

We started banding Little Brown Bats around Lake of the Woods (mainly in the Kenora area) in 1993 to learn whether those populations use Manitoba caves to hibernate. Band returns demonstrate that at least some of those females forming nursery colonies in that region definitely use central Manitoba caves to over-winter, as well as one nearby abandoned mine. It has been speculated for some time that abandoned mines in the Kenora area have served as hibernacula (Nagorsen 1980). In July 1995, we were directed to an abandoned mine at Richard Lake, 37 km east of Kenora and, upon returning in late September, found it to contain at least 250 Little Brown Bats, none previously banded. In the Richard Lake hibernaculum in subsequent years we recaptured banded bats from nursery colonies on Lake of the Woods (Keewatin, French Portage Narrows, Rushing River Provincial Park), as well as bats previously banded in Manitoba hibernacula as far as 533 km away (St. George, Iguana Crypt and Microwave caves).

Conservation

This study has verified that at least 11 caves in Manitoba and one abandoned mine in northwestern Ontario serve as hibernacula for Little Brown Bats (Table 1). Bats of many species are at their most vulnerable at roost sites, particularly hibernacula (Brigham 1993). The largest hibernaculum discovered to date in Manitoba, by several orders of magnitude, is St. George Cave, 200 km north of Winnipeg. More than 20 000 little browns spend each winter in that cave. This critical cave and a small area around it was declared an ecological reserve by the Province of Manitoba on 15 March 1997, after several years of effort by Willard Anderson, the authors, and other members of the Speleological Society of Manitoba. This is the most stringent legal protection a natural feature can get in this province. The Province of Manitoba, on 15 January 1996 officially declared six species of bats to be "a wild animal" under *The Wildlife Act* (by the Designation of Wild Animals Regulation MR 3/96), as a first step in their protection. As of December 1997, Manitoba Department of Natural Resources (now Conservation) has issued guidelines to direct all activities occurring on Crown land around the known over-wintering caves (Asmundson and Larche 1996*).

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Immobilization of Elk, *Cervus elaphus,* with Telezol and Xylazine and Reversal with Tolazine or Yohimbine

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During January 2003 and March 2005, a Telazol®/xylazine mixture was used to immobilize 4 free-ranging Elk in Ontario, Canada. A dosage of 3.3-3.6 mg/kg of Telazol® and 1.7-2.0 mg/kg of xylazine proved to be effective for the rapid immobilization of Elk. Induction time for those dosages was as short as 3-4 minutes. The advantage of using Telazol® is that only small volumes (3-4 ml) are needed to immobilize Elk-sized animals. In addition, Tolazine® and yohimbine both proved to be effective antagonists for xylazine with recovery times of 8 to 15 minutes when administered at dosages of 3.3-3.6 and 0.08-0.14 mg/kg, respectively. The use of oxygen proved to be effective for treatment of hyoxemia in Elk immobilized with a Telazol®/xylazine mixture. The immobilization procedures and the drug and antagonist dosage information will be useful to researchers planning to capture free-ranging Elk for activities such as radio-collaring and blood sampling.

Key Words: *Cervus elaphus,* Elk, antagonist, immobilization, reversal agent, Telazol®, Tolazine, Yohimbine, Ontario.

During 1998 – 2001, 443 Elk (*Cervus elaphus*), also known as American Elk, or Wapiti, were transported from Elk Island National Park (EINP), Alberta, and released in four areas of Ontario, Canada (Bellhouse and Rosatte 2005; Rosatte et al. 2007). One of the release sites, near Bancroft, Ontario (approximately 44°5'N, 77°30'W), received 120 Elk during 2000 and 2001. All Elk were aged and weighed at EINP during processing, which included ear-tagging and fitting the Elk with telemetry collars (VHF and GPS) (Rosatte et al. 2002). The weights of Elk at EINP were used as guidelines to estimate the weight of Elk in Ontario for drug dosage calculations.

As ten of the Elk were fitted with GPS collars during processing at EINP, some of the animals had to be immobilized to retrieve the collars and download the data. On 16 January 2003 (-20°C), an 8 year old, free-ranging adult cow Elk (ear tag 341), previously fitted with a GPS collar (148.188 Mhz) at EINP, Alberta, was immobilized with Telazol® (tiletamine hydrochloride and zolazepam hydrochloride) (Fort Dodge Animal Health, Fort Dodge, Iowa) and AnaSed (xylazine hydrochloride) (Vet-A-Mix, Shenandoah, Iowa) near Bancroft, Ontario, for the purpose of collar removal. The drug dosage (target dosage was about 3 mg/kg Telazol® and approximately 1.5 mg/kg of xylazine) was calculated using an estimated weight for the Elk of 236 kg – her weight during processing at EINP in January 2001. The immobilizing drug mixture was prepared by injecting the desired volume and weight of xylazine into a bottle containing lyophilized Telazol®. The Telazol®/xylazine mixture was then drawn off with a syringe and injected into the immobilization dart. The dart was then plugged with vasoline to prevent the leakage of drugs from the dart. A Model 193 Pneu-Dart 50 caliber rifle and 4× scope (Pneu-Dart Inc., Williamsport, Pennsylvania) with a yellow CCI 22 caliber brass power charge (Omaha Industries, Lewiston, Idaho) and a diffuser setting of 4, was used to project a 50 caliber, 4 cc aluminum type C dart with a 3 cm long barbed needle (Pneu-Dart Inc., Williamsport, Pennsylvania), that contained the Telazol®/xylazine mixture, into the hind leg musculature of the Elk. The distance of the shot was about 35 m. As soon as the animal was in a lateral recumbent position and there was no evidence of leg or eye reflex, she was moved into a sternal recumbent position and the head was elevated to minimize the chance of bloat and regurgitation of rumen contents. Ophthalmic ointment was applied to the eyes of the immobilized Elk to prevent drying. The respiration rate of the cow Elk was about 18/min at 30 min post-darting. At 36 min post-darting, the respiration rate increased to 54/min and breathing was very shallow. At this point, bloat was evident and the gum/ tongue area was blue in color (indicative of low oxygen content in the blood). The animal was administered oxygen orally as a treatment for hypoxemia, as well as rolled side to side in an effort to relieve the bloat. The head was elevated and lowered as well to stimulate belching. At 50 min post darting, respiration rate decreased to 42/min and the tongue/gum area returned to a pinkish color following the administration of oxygen. Hibitane antibacterial veterinary ointment (1% chlorhexidine acetate) (Ayerst, Guelph, Ontario) was applied to the dart wound. After the animal was processed an intramuscular injection of Tolazine (tolazoline hydrochloride, Lloyd Laboratories, Shenandoah, Iowa) was administered in the right leg musculature to speed recovery. The concentration and dosage of drugs as well as the induction, down and recovery times are shown in Table 1. After the animal was in a standing position, she orally expelled gas for several

seconds and the bloat decreased dramatically. The Elk was monitored for the next few days and no adverse effects were noted. She was still in good health when observed near Bancroft, Ontario in April 2005.

On 19 February 2004 (-6°C), a 10.5 year old cow Elk (ear tag 360) was immobilized near Bancroft, Ontario, to remove a GPS collar (149.560 Mhz). The weight of the animal at EINP during January 2001 was 234 kg. The animal was darted with a mixture of Telazol®/xylazine as described above using a Pneu-Dart rifle, with a yellow 22 caliber power charge and a diffuser setting of 3, and a 4 cc dart. The distance of the shot was about 25 m with the dart hitting the right upper hind leg musculature. As the drug took effect the Elk assumed a recumbent position beginning with the hind end first (Figure 1). Some bloat was evident so oxygen was administered for treatment of hypoxemia and the animal was rolled from side to side and the head elevated to expel gases (Figure 2). Respiration rate increased from about 14/min to 70/min when bloating occurred. The gums and tongue remained pink colored throughout the handling period. When processing was complete, Tolazine was injected intramuscularly to reverse the effects of xylazine and speed recovery from the drug. Induction, immobilization and recovery times are noted in Table 1.

On 11 January 2005 (-17°C ambient temperature), a yearling bull Elk, born in Ontario, suspected of being infected with meningeal worm (*Parelaphostrongylus tenuis*), was immobilized with an intramuscular injection of Telazol® and xylazine hydrochloride for the purpose of collecting a blood sample. The dosage of drug was calculated using mean weights of yearling bull Elk at EINP. As the Elk had no fear of humans, possibly due to the effects of *P. tenuis*, the drugs were administered intramuscularly in the right upper hind limb area via a 5 cc sterile syringe (Burron Medical Products, Bethlehem, Pennsylvania, USA) and 22 g (4 cm) needle (Terumo, Belgium) attached to a jab stick made from a piece of copper tubing. When processing was complete, which included radio-collaring (148.412 Mhz) and ear-tagging (#139) (as reported in McIntosh et al. 2007), the Elk was injected intramuscularly in the hind limb musculature with Yobine (yohimbine hydrochloride) (Lloyd Laboratories, Shenandoah, Iowa, USA) as a reversal agent for xylazine. Drug dosages, induction, immobilization and recovery times are presented in Table 1. While immobilized, respiration rate for the yearling bull Elk was 14-16/min, there was no evidence of bloat, and the gums and tongue remained pink in color.

On 30 March 2005 (+5°C ambient temperature), a 2½ year old bull Elk (born in Ontario) was immobilized with Telazol® and xylazine for the purpose of de-antlering as the animal had broken the pedicle in the fall of 2004. The drugs were administered as described above using a Pneu-Dart rifle, with a green 22 caliber power charge, a diffuser setting of 5, and a 4cc dart. The distance of the shot was about 30 m with the dart hitting

TABLE 1. Drug dosages, induction, immobilization and recovery times for Elk injected intramuscularly with a mixture of Telazol® and xylazine with either Tolazine or Yobine being used as an antagonist.

Date	Age/ sex[a]	Weight (kg)[b]	Weight of Telazol®/ Xylazine (mg)[c]	Dosage of Telazol®/ Xylazine (mg/kg)	Reversal agent	Weight of reversal agent (mg)	Dosage of reversal agent (mg/kg)[c]	Induction time (min)[d]	Down time (min)[e]	Recovery time (min)[f]	Respiration rate during processing (breaths/min)
01/16/03	AF	225	800/375	3.6/1.7	Tolazine	800	3.6	10[g]	45	15	10-54
02/19/04	AF	225	800/375	3.6/1.7	Tolazine	750	3.3	3	52	15	14-70
01/11/05	YM	150	500/300	3.3/2.0	Yobine	12	0.08	4	90	14	14-16
03/30/05	AM	170	500/350	2.9/2.1	Yobine	24	0.14	16	46	8	12-14

[a] AF = Adult Female; YM = Yearling Male; AM = 2 ½ yr old Male.

[b] Weight was estimated using weights of Elk at EINP and body size and age of elk.

[c] Concentration of drugs were: Telazol® - 100 mg/mL; Xylazine – 100 mg/mL; Yohimbine 2 mg/mL; Tolazine – 100 mg/mL.

[d] Induction time is the time from drug administration to when the animal was in lateral recumbency.

[e] Down time is the time from when the animal was first immobilized until it was in a standing position.

[f] Recovery time is from the time when the reversal agent was injected until the animal was standing.

[g] 10 min is an overestimate of induction time as the animal was not be located in the forest until 10 minute after darting.

FIGURE 1. A GPS collared adult cow Elk (ear-tag 360) exhibiting hind limb paralysis 2 minutes after being darted with a mixture of Telazol® and Xylazine. (Photo by R. Rosatte).

the right upper hind leg musculature. Respiration rate was stable at about 12/min during processing (de-antlered and ear-tagged – #141) and the gums and tongue remained pink colored with no evidence of hypoxemia or bloat. A 3 cc intramuscular injection of Dystosel (Vitamin E – 136 IU/mL and selenium – 3 mg/mL) (Pfizer Canada Inc, London, Ontario) was administered as a preventative measure against capture myopathy. When processing was complete, Yobine was injected intramuscularly to speed recovery from the effects of xylazine. Induction, immobilization and recovery times are shown in Table 1.

Discussion

A dosage of 3.3-3.6 mg/kg (body weight) of Telazol® and 1.7-2.0 mg/kg of xylazine proved to be an effective drug combination for the rapid immobilization of four free-ranging Elk in Ontario. Induction time or the time from darting until the animal was prone for those dosages was 3-4 minutes. This calculation did not include the Elk for which induction time was noted as 10 minutes, as that animal was not immediately located in the forest. Similarly, Millspaugh et al. (1995) reported a mean induction time of 4.6 minutes when Elk were immobilized with 2.5 mg/kg Telazol® and 0.3 mg/kg xylazine. The advantage of using a Telazol®/xylazine mixture over a drug combination such as ketamine hydrochloride (at a commercially available concentration 100 mg/mL)/xylazine is that a much lower volume of Telazol is required to attain a state of immobilization. For example, only a 4 mL (800 mg of Telazol® reconstituted in 3.5 mL of xylazine) volume of drug was required to immobilize a 225 kg cow Elk. About 15 mL of a ketamine hydrochloride/xylazine hydrochloride (100 mg/mL ketamine) mixture was required to immobilize a bull Elk in Ontario during 2003. The advantage of a smaller volume of Telazol®/xylazine mixture is that a much smaller dart can be used (4 cc compared to a 10 or 15 cc) to administer the drugs, which means less weight and less damage to the animal when the dart is administered via an immobilization gun. A smaller dart (4 cc) has a better trajectory and is more accurate at longer distances (> 65 m) than a larger/heavier dart (10-15 cc). In addition, as the induction time for ketamine in Elk is generally longer than that for Telazol®, animals tend to move farther before being completely immobilized (Golightly and Hofstra 1989; Miller et al. 2004), which could result in problems locating the animal in heavily forested areas.

FIGURE 2. Oxygen being administered to the immobilized cow Elk (ear tag 360) for treatment of hypoxemia (Photo by R. Rosatte).

One drawback with using a Telazol®/xylazine mixture for the immobilization of Elk is the extended recovery time which could lead to decreased survival. In one study, an Elk immobilized with a Telazol®/xylazine mixture was not administered an antagonist and was immobilized for 5 hours (Golightly and Hofstra 1989). As well, there is no known antagonist for the tiletamine component of Telazol® (Miller et al. 2004). Tolazine and yohimbine both proved to be effective antagonists for xylazine with recovery times of 8 to 15 minutes when administered at dosages of 3.3-3.6 and 0.08-0.14 mg/kg (body weight), respectively. However, the key to rapid recovery was administering the antagonist 45-60 minutes (or longer) post -immobilization. This allowed sufficient time for Telazol® to be metabolized and diminish side-effects after injection of the reversal agent. Animals may stagger for some time due to the effects of Telazol® if the antagonist is administered too soon after immobilization as the antagonist only neutralizes the effects of xylazine. Millspaugh et al. (1995) reported a mean recovery time of 14 minutes when yohimbine was administered intravenously to reverse xylazine administered to Elk at a dose of 0.3 mg/kg (in a mixture with Telazol® at a dose of 2.5 mg/kg). However, a recovery time in that study of 125 min was reported when yohimbine was given intramuscularly.

Hypoxemia or deficient oxygenation of the blood may occur during the immobilization of wild ruminants. This can lead to organ failure and capture myopathy (Read et al. 2001). Bloating occurred in two of the Elk immobilized in this study despite their being in a sternal recumbent position. As well, respiration rate was high in those two Elk {normal respiration rate for elk is about 13 breaths/min (Hudson and Haigh 2002)}. Bloat is a result of gas production in the rumen, which may result in pressure being applied to the diaphragm (due to the weight of the abdominal viscera on the diaphragm) with resultant respiratory/circulatory problems and oxygen depletion in the blood. Bloating in this study may have been aggravated due to the animals foraging at feeding stations (with alfalfa) prior to darting. Oxygen quickly relieved the symptoms of hypoxemia (blue tongue, lips), and the suggested rate of oxygen administrated nasally for preventing hypoxemia was 10 L/min for a period of about 5 minutes (Read et al. 2001).

The four immobilized Elk were later (1 month to 2 years) located by radio-telemetry and had recovered fully, with no observable side effects from immobiliza-

tion or handling. Capture procedures, drugs and antagonist data outlined above will be useful to researchers planning to capture free-ranging Elk. For "off-label" use of the above drugs on wild animals such as Elk, an "Emergency Drug Release Authorization" must be approved by the Veterinary Drugs Directorate, Health Canada, and animals immobilized with agents such as Telazol® are not to be used as food items.

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First Confirmed Breeding of the Marbled Godwit, *Limosa fedoa*, in Québec

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The objectives of this study were to confirm breeding of the Marbled Godwit (*Limosa fedoa*) in Rupert Bay, on the Quebec coast of James Bay, and to assess population abundance. Nest search was conducted 17–20 June 2003, using several techniques. Two nests were found in the high marsh of Cabbage Willows Bay: these are the first confirmed breeding records of this species in Québec. The Rupert Bay region probably holds a breeding population of no more than a few dozen pairs.

Cette étude visait à confirmer la reproduction de la Barge marbrée (*Limosa fedoa*) dans la baie de Rupert située sur la côte est de la Baie James (Québec) et à estimer l'abondance de la population. Une recherche de nids a été réalisée entre le 17 et le 20 juin 2003 à l'aide de différentes techniques. Deux nids ont été découverts dans le haut marais de la baie Cabbage Willows. Ils confirment pour la première fois le statut nicheur de cette espèce au Québec. La région de la baie de Rupert abrite probablement une population nicheuse d'au plus quelques douzaines de couples.

Key Words: Marbled Godwit, *Limosa fedoa*, nest search, breeding, abundance, James Bay, Rupert Bay, Cabbage Willows Bay, Québec.

The Marbled Godwit (*Limosa fedoa*) breeds only in North America, in three disjunct areas: the grassland of the northern United States and southern Canada, the Alaska Peninsula, and James Bay (Gratto-Trevor 2000). The James Bay area probably holds only 1000–2000 birds (Gratto-Trevor 2000), but the species breeding has been confirmed only in Ontario (Morrison et al. 1976; Peck and James 1983; Morrison 1987).

In Québec, the species was first recorded on the James Bay coast by Spreadborough (*in* Macoun and Macoun 1909), who stated that the species bred on both coasts in 1904, although no direct evidence for breeding was reported. The Marbled Godwit was not recorded again on the east coast of James Bay before 1990. Since then it has been observed during the breeding season in and near Rupert Bay (Létourneau and Morrier 1996). Breeding behaviours were noted there in 1990 and 1991, but nesting was not confirmed.

In 2003, as part of the Eastmain-1-A and Rupert diversion hydroelectric project environmental studies, we sought to clarify the breeding status of the Marbled Godwit in Rupert Bay, on the Québec side of James Bay. The objectives of this study were to confirm breeding of the species in Québec and to assess population abundance.

Study Area and Methods

Field work was carried out in the coastal wetlands of Rupert Bay, Québec, Canada (Figure 1). These wetlands are particularly well developed owing to the sandy deposits and flat landscape. They are especially extensive in Cabbage Willows Bay, which opens into Rupert Bay, and Boatswain Bay, which opens directly into James Bay, but are narrower in Hall Cove and elsewhere. They consist, in sequence from upland to open water, of swamps, fens, high marshes and low marshes (FORAMEC 2004*). The high marsh grounds are somewhat spongy but not covered by water. Low marshes are covered twice daily by the tide but the other wetlands are flooded only by storm tides and equinoctial tides.

Nest searches were conducted on 17–20 June 2003, using several techniques. The rope-drag method (Klett et al. 1986) was used on 0.3–1.4 km transects in parts of the high coastal marsh of Cabbage Willows Bay and Hall Cove. Nests were also searched for in the same areas by watching birds flying from the low marsh to potential nesting areas or vice versa. In addition, playbacks of taped breeding calls were used regularly on the high marsh and once in the low marsh. Finally, to increase ground coverage, we conducted a helicopter survey in Cabbage Willows Bay, in Hall Cove, over some Tamarack (*Larix laricina*) fens on Ministikawatin Peninsula, and on Jacob Island, north of Rupert Bay. We searched along 50-m parallel transects, at speeds that varied from 20 km/h to hover, and at altitudes varying from 3 to 9 m.

Breeding chronology was estimated assuming a mean egg-laying interval of 2 days and an incubation period of 25 days (Gratto-Trevor 2000). Abundance was estimated with counts of birds performing aerial display and nests.

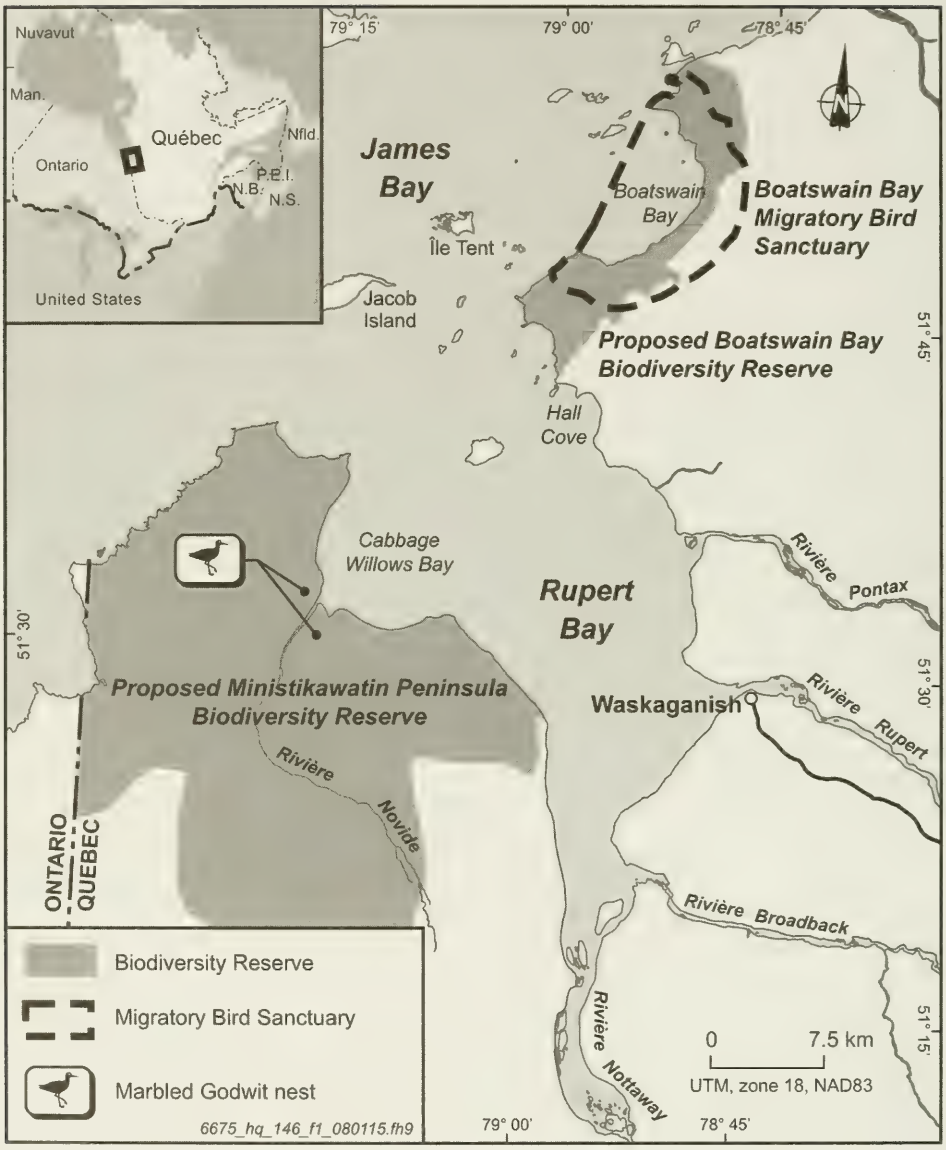

FIGURE 1. Location of Marbled Godwit study area and nests.

Results

The Marbled Godwit nest search was conducted on slightly over 20 km of line transects using the rope-drag method. It covered about 70 ha.

Two Marbled Godwit nests, 3.6 km apart, were discovered in the high coastal marsh of Cabbage Willows Bay in 2003 (Figure 1). The first nest (51°32.61'N, 79°16.13'W), containing four eggs (Figure 2) and one adult incubating, was found on 17 June using the rope-drag technique. The second nest (51°30.77'N, 79°15.13'W), discovered on 20 June following observation of courtship behaviour, contained only one egg, but two adults were within 30 m of the nest. The first nest was revisited again on 19 June and still contained four eggs.

Nests were 5 cm in depth and 20 cm in diameter at the rim. They were mostly, if not completely, made of dry stems of Sweet Grass (*Hierochloe odorata*). Both nests were found in the largest clumps of that species in the vicinity. The first nest was partly covered by

FIGURE 2. First Marbled Godwit nest discovered in Rupert Bay, Québec.

green stems. Throughout the high coastal marsh, grass cover, about 10–15 cm tall, was relatively sparse, with occasional clumps up to 15–25 cm.

In 2003, laying and potential incubation in Cabbage Willows Bay occurred at least between 11 June and 19 July.

No Godwit responded to several playback trials in the high coastal marsh. However, two individuals answered spontaneously to the single trial on the low coastal marsh, by flying and calling around the investigators. Over the same biotope, four different birds were seen engaging in aerial courtship behaviour during nest searches. Besides the birds associated with the nests, only one Marbled Godwit was seen in the high marsh: it was flying from the low marsh and landed in the high marsh, on a potential nesting area. Despite a long search, it was not seen again.

Partial aerial coverage of the Cabbage Willows Bay low coastal marsh enabled us to identify four adults. Another bird was spotted as it flew toward the low marsh during the aerial survey; it seemed to be coming from the second nest area. No birds were seen in Hall Cove or in Ministikawatin Peninsula or Jacob Island during aerial surveys.

Discussion

The two Marbled Godwit nests that we found in Cabbage Willows Bay represent the first definitive breeding evidences of this species in Québec. Some previous observations had led us to believe the species was nesting there. On 17 June 1991, two copulating birds were observed in Cabbage Willows Bay. The same year, three Marbled Godwits were seen on 21 July in the same area, including two agitated birds giving alarm calls, indicating the probable presence of young (Létourneau and Morrier 1996). Finally, a similar observation was recorded on 27 July 2002, again in Cabbage Willows Bay, north of the Novide River (Hydro-Québec, unpublished data).

Breeding habitat in Cabbage Willows Bay is similar to that described elsewhere. In North Dakota, the Marbled Godwit shows a strong preference during breeding season for short, sparse to moderately dense cover along wetland shorelines and shorter vegetation in upland habitats (Ryan et al. 1984). In James Bay, Ontario, one nest was found in a raised, grassy ridge between two ponds, in an open coastal marsh (Peck and James 1983).

Estimated breeding chronology suggested that nest search was carried out in the egg-laying and early incubation period. This is consistent with the observed copulation (17 June 1991) and other previous records suggesting breeding (see above). The flight displays observed in 2003 also support the breeding chronology outline. Display behaviour is most frequent early in the breeding season and is commonly performed by

unpaired or nest-scraping males until incubation duties are initiated (Nowicki 1973). In Ontario, two breeding records from James Bay indicate that egg-laying was initiated approximately between 24 May and 31 May (Morrison et al. 1976; Peck and James 1983).

In 2003, the Marbled Godwit breeding population included at least four pairs in Cabbage Willows Bay. In 2002, the species was also recorded in Boatswain Bay, Jacob Island and Tent Island, between 23 July and 1 September (Hydro-Québec, unpublished data). However, considering the late dates and that no breeding behaviour was observed, it is likely that these birds were migrants rather than breeders. Although no Marbled Godwit was recorded during the aerial survey inland of Ministikawatin Peninsula, the species was located there in June 1990 and 1991, in three areas, including a bird on a shallow lake fen (Létourneau and Morrier 1996). In Ontario, the Marbled Godwit is also found up to 20 km inland (Gratto-Trevor 2000). Thus, the species probably breeds inland of Ministikawatin Peninsula. Its abundance there could exceed that of Cabbage Willows Bay because of the vast expanse of Tamarack fens. On 15 June 1991, 80 Marbled Godwits were counted in Cabbage Willows Bay (Létourneau and Morrier 1996). Their breeding status is questionable. As noted earlier, that date probably coincides with egg-laying and early incubation. Either these birds were on the point of dispersal for local breeding or were migrants on the way to northern James Bay breeding grounds in Ontario. However, if Marbled Godwits fly directly to breeding areas in spring from wintering sites on southeastern U.S. coasts, as the reverse is presumed to occur in the fall (Morrison et al. 1976), then those birds may have been local or regional breeders. Therefore, the Rupert Bay region probably holds a breeding population of between four pairs and a few dozens pairs.

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Swift Fox, *Vulpes velox*, Den Use Patterns in Northwestern Texas

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Predator avoidance may be a reason why Swift Foxes (*Vulpes velox*) are one of the most burrow-dependent canids in North America. Typically Swift Foxes have multiple dens, which they frequently move among. As part of a larger study to reduce Coyote (*Canis latrans*) related mortalities on Swift Foxes, we installed artificial escape dens in areas occupied by Swift Foxes on Rita Blanca National Grassland, Dallam County, Texas. For this paper, our objective was to determine the effects of artificial escape dens on Swift Fox den use patterns. From January 2002 to August 2004 we captured, radio-collared, and monitored 55 Swift Foxes. We documented annual number of dens used, rate of den use (fidelity), distance between dens, den area, and den sharing. We compared treated (artificial dens installed) and untreated (no artificial dens) areas but found no differences in annual number of dens ($P = 0.64$; $\bar{\chi} = 8$), rate of den use ($P = 0.96$; $\bar{\chi} = 35\%$), mean distance between dens ($P = 0.99$; $\bar{\chi} = 2{,}311$ m), den area ($P = 0.55$; $\bar{\chi} = 5.72$ km^2), or den sharing ($P = 0.46$; $\bar{\chi} = 42\%$ of time). We did not observe an effect of artificial escape dens on Swift Fox den use patterns probably because artificial escape dens were designed for temporary escape cover rather than diurnal den use.

Key Words: Swift fox, *Vulpes velox*, den range, den sharing, den use, fidelity, Texas.

Swift Foxes (*Vulpes velox*) were once abundant throughout the short and mid-grass prairies of North America but have rapidly declined with expansion of human settlement (Egoscue 1979). Studies have shown that the Swift Fox primarily inhabits areas of native rangeland (Allardyce and Sovada 2003). Much of the historical Swift Fox range has been fragmented into patches of native rangeland, Conservation Reserve Program, and agricultural fields (Allardyce and Sovada 2003). Habitat loss has been one of the reasons Swift Foxes were temporarily a candidate for endangered species listing with the United States Fish and Wildlife Service (USFWS) from 1992 to 2001 (USFWS 1995; USFWS 2001; Allardyce and Sovada 2003).

Predation has been another limiting factor on Swift Fox populations (Kamler et al. 2003a). Many studies have shown that Coyotes (*Canis latrans*) are the primary source of Swift Fox mortality, with annual survival rates ranging from 43 to 53% (Sovada et al. 1998; Kitchen et al. 1999; Matlack et al. 2000; Anderson et al. 2003; Allardyce and Sovada 2003). Because Coyotes rarely consume Swift Foxes they kill (Sovada et al. 1998; Kitchen et al. 1999; Allardyce and Sovada 2003), Coyote predation seems to be the result of both interference and exploitative competition (Kamler et al. 2003b).

Predator avoidance may be one reason why Swift Foxes are one of the most burrow-dependent canids in North America (Moehrenschlager et al. 2004). Dens are an integral part of Swift Fox ecology. Swift Foxes use dens year-round not only for protection from predators, but also for reproduction, resting, and avoidance of extreme climatic conditions (Egoscue 1979). In sparsely vegetated habitats occupied by Swift Foxes, dens may constitute crucial escape cover. Arjo et al. (2003) found the number of dens used by Kit Foxes (*Vulpes macrotis*) was positively correlated with Coyote numbers. In addition, White et al. (1994) suggested that Kit Foxes established a number of dens (≥20) to facilitate escape.

It has also been suggested that Swift Foxes move frequently among different den sites (Kilgore 1969; Hines and Case 1991), but little detail on den use patterns has been reported. Understanding Swift Fox den behavior may be an important factor in sustaining viable populations throughout their range.

Because Swift Foxes use dens year-round (Egoscue 1979), we installed artificial escape dens as part of a larger study to determine if lack of den sites limited Swift Fox populations in northwest Texas, USA (McGee 2005). The objective of this paper was to document the effects of artificial escape dens on Swift Fox den use patterns. We determined annual number of dens used, rate of den use (fidelity), distances between dens, den area, and den sharing. We predicted that with more dens available in treated areas Swift Foxes would use more dens, have less fidelity for certain dens, have greater distances between dens, and be less likely to share a den. We made comparisons between treated (artificial escape dens installed) and untreated (no artificial dens installed) areas.

Study Area

We collected data from a contiguous 100-km^2 area on the Rita Blanca National Grassland (NG) in Dallam County, Texas, approximately 43 km northwest of Dalhart, Texas (Figure 1). The NG consisted of native rangelands with short-grass prairie dominated by Blue Grama (*Bouteloua gracilis*), Side-oats Grama (*Bouteloua curtipendula*), Burrograss (*Haplopappus tenui-*

sectus), and Buffalograss (*Buchlöe dactyoides*) that were moderately to intensively grazed by cattle (*Bos taurus*; Kamler et al. 2003a,b; Nicholson 2004; McGee 2005).

Methods

We captured, handled, and radio-collared Swift Fox using methods described by McGee (2005). We tracked Swift Fox to their diurnal resting sites (dens) using a hand-held antenna 1–2 times per week. We recorded each den location with a Garmin global positioning system receiver (Garmin International Inc., Olathe, Kansas, USA). We only used Swift Fox that were monitored ≥8 months of the year in data analysis. We calculated annual estimates from September to August of each year for all analyses. This was to allow Swift Foxes an adjustment period after installation of artificial dens and to perform two full years of data analysis.

During April 2002, we placed 108 artificial escape dens in three spatially separated areas (Figure 1). We considered Swift Foxes belonging to a treated area if their home ranges overlapped an artificial escape den area by ≥50%. We considered untreated Swift Foxes as those whose home ranges did not overlap artificial escape den areas (McGee 2005). No Swift Foxes in untreated groups were ever located within an artificial escape den treated area. Also, we considered foxes to belong to the same family group if they used the same area and dens concurrently (Kitchen et al. 1999; Kamler et al. 2003a,b).

Escape dens consisted of corrugated plastic sewer pipes 4.04 m long, 20.32 cm diameter with 20.32 cm holes cut in the middle to allow foxes to modify and expand subterranean dens ($6.41/m U.S.; Amarillo Plumbing Supply, Inc., Amarillo, Texas, USA). The diameter size of our artificial escape dens was based on previous studies that reported a mean den opening height of 20.0 cm for Swift Fox dens (Cutter 1958; Hillman and Sharps 1978; Pruss 1999; Jackson and Choate 2000). Coyote dens were reported to be 30–37 cm in diameter (Bekoff 1977; Althoff 1980; Bekoff 1982; Harrison and Gilbert 1985). We assumed that artificial escape den entrances, being the same diameter as natural Swift Fox dens, were too narrow for Coyotes. A John Deere 260 skid loader (Deere and Company World Headquarters, Moline, Illinois, USA) was used to install and cover the sewer pipe with only the two open ends exposed. Escape cover was randomly oriented and spaced approximately 322 m apart in a 2.59 km^2 grid pattern for a density of 36/2.59 km^2 (McGee 2005).

We calculated rate of den use (fidelity) by dividing number of dens by the number of times the fox was located in dens (× 100%). Lower values represented higher den fidelity. We calculated distances between dens using Bearing and Distance Extension for ArcView 3.2 (Environmental Systems Research Institute, Redlands, California, USA). We used den locations to estimate annual den areas for Swift Foxes using 100% minimum convex polygon (MCP) method (Mohr 1947) as calculated by Home Range extension (Rodgers and Carr 1998) for ArcView 3.2 (Environmental Systems Research Institute, Redlands, California, USA). We calculated den sharing as percentage of time a radio-collared Swift Fox was found in a den with another radio-collared fox.

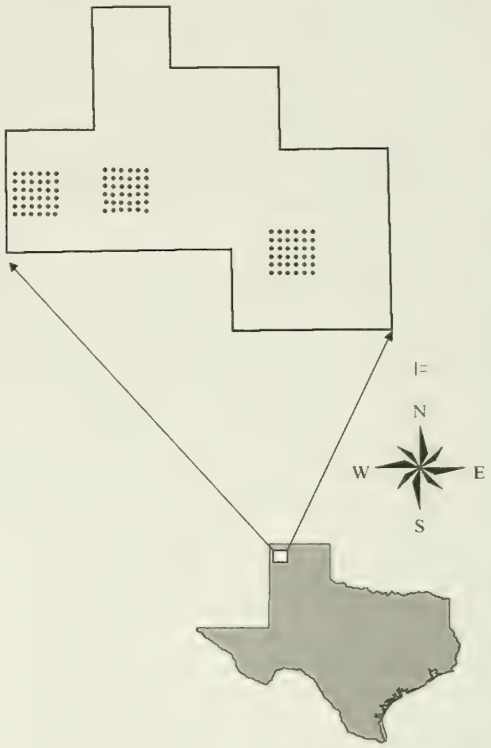

FIGURE 1. Map of the 100-km^2 study area located on the Rita Blanca National Grassland in northwest Dallam County, Texas, USA. One hundred and eight artificial escape dens (black dots) where installed in three separate grid locations.

We found no statistical differences among years so we pooled data to increase power. We used 1-way ANOVAs in SPSS 12.0 (SPSS 2003) to determine differences between treated and untreated areas for annual number of dens used, mean distances between dens, and mean den areas. We compared average rate of den use and sharing between treated and untreated areas using Yates' corrected chi-square tests (Zar 1999). Differences were deemed significant when $P < 0.05$.

Results

From January 2002 to August 2004, we captured and radio-collared 55 Swift Foxes (31 males, 24 females). We documented a total of 104 Swift Fox dens

Table 1. Average annual number of dens and den area of Swift Foxes on Rita Blanca National Grassland (NG) in northwest Texas, 2002–2004.

		Annual number of dens		Den range (km^2)	
Study area	n	$\bar{\chi} \pm$ SE	range	$\bar{\chi} \pm$ SE	range
treated	8	7.88 ± 0.48	6–10	6.34 ± 1.86	0.52–13.21
untreated	4	7.50 ± 0.50	7–9	4.50 ± 1.91	0.81–9.20

during our study including four separate occasions when we radio-tracked and observed Swift Foxes within artificial escape dens during the day. Due to the high turnover rate in our Swift Fox population, only 12 Swift Foxes (n = 8 treated, n = 4 untreated) were monitored for ≥8 months a year from September 2002 to August 2004.

There was no difference (P = 0.64) in annual number of dens used (mean ± SE) by Swift Foxes between treated (7.88 ± 0.48, n = 8) and untreated (7.50 ± 0.50, n = 4) areas (Table 1). Average rate of den use (fidelity) was similar (Yates' χ^2 = 0.003, P = 0.96) between treated (35.9%) and untreated (35.4%) areas. Mean distance between dens (± SE) was not different (F < 0.001, P = 0.99, 1-β = 0.05) between treated (2308 ± 442 m, n = 8) and untreated (2317 ± 654 m, n = 4) areas. There was no difference in den area (F = 0.38, P = 0.55, 1 − β = 0.09) between treated (6.34 ± 1.86 km^2, n = 8) and untreated areas (3.81 ± 1.91 km^2, n = 4). Den sharing only occurred between mated pairs. Average rate of den sharing was similar (Yates' χ^2 = 0.56, P = 0.46) between treated (44.9%) and untreated (39.0%) areas.

Discussion

We have shown that average number of dens used by Swift Fox each year was eight in northwest Texas (Table 1). Schauster et al. (2002) documented number of Swift Fox dens used was 2–8 for breeding and gestation season, 5–10 for pup-rearing season, and 3–8 for the dispersal season. Similar multiple den use has been documented with other small canids that share a dependence on dens, such as Artic Fox (*Alopex lagopus*; Eberhardt et al. 1983) and Kit Fox (Tannerfeldt et al. 2003; Moehrenschlager et al. 2004). Koopman et al. (1998) reported an average of 11.8 dens per year for Kit Foxes in California. Arjo et al. (2003) suggested to an increase in the number of dens used by Kit Foxes in western Utah could have been related to the increase in Coyote presence.

We found that Swift Foxes had relatively high fidelity to particular dens for both treated and untreated areas. Koopman et al. (1998) found that Kit Foxes exhibited a strong affinity for particular dens because Kit Foxes were located in their most frequently used den 32% of the time. Artic Foxes also preferred certain dens while others were used infrequently (Eberhardt et al. 1983). We suspect that den fidelity may be the result of den quality. Distinctions have been made between good and bad dens for Artic Foxes (Tannerfeldt et al. 2003). On the other hand, Swift Foxes frequently switch between dens (Egoscue 1979; Hines and Case 1991), suggesting poor den quality. One of the reasons for frequent changes between dens has been attributed to the large numbers of fleas found in Swift Foxes' dens (Kilgore 1969). Other factors like human disturbance, leaking, shifting towards food resources, and predator avoidance may play a role in Swift Foxes den switching and fidelity (Kilgore 1969; Tannerfeldt et al. 2003).

In addition, we documented a mean distance between dens of 2311 m (range 729–3998 m). Similarly, Moehrenschlager (2000) found that Swift Foxes in Canada moved to dens up to 1900 m away. In contrast, Cutter (1958) noted that Swift Fox dens in overgrazed pastures of northern Texas were concentrated but did not state the distance between dens. Cutter (1958) noted that up to six dens were frequently observed within 65 hectares of pastureland. Greater distances between dens would allow Swift Foxes access to more resources within their environment if dens were used to escape predators.

It has been suggested that carnivore home-range size can be affected by habitat composition and food distribution (Macdonald 1983). White and Ralls (1993) observed that larger Kit Fox home ranges were associated with low prey availability. We suspect that these effects can be applied to den area of Swift Foxes as well. Our results indicated a mean den area of 5.72 km^2. It is possible that Swift Foxes with larger den areas may have had greater access to food resources while avoiding predators. Ables (1969) recognized that Red Fox (*Vulpes vulpes*) home range size was affected by food abundance and availability. In addition, Hines and Case (1991) speculated that carrion availability and prey distribution probably affected Swift Fox home range size and shape. Likewise, Olson and Lindzey (2002) suggested that intensive hunting by Swift Foxes near natal dens may have reduced prey availability and consequently forced adults to expand the areas in which they hunted. Thus, larger den areas may be the result of fewer resources (Hines and Case 1991).

Although additional adult foxes have been observed with mated pairs at Swift Fox (Egoscue 1979; Covell 1992; Kitchen et al. 1999; Lemons et al. 2003), Arctic Fox (Eberhardt et al. 1983), and Kit Fox (Ralls et al. 2001; Tannerfeldt et al. 2003) den sites, we did not document this occurrence. Of the Swift Foxes that we monitored, only mated pairs were ever found occupy-

ing the same den. Adult radio-collared Swift Foxes in our study denned with their mate 39–44% of the time. Similarly, Koopman et al. (1998) found that mated adult Kit Foxes denned together about 45% of the time. Also, Ralls and White (2003) found that Kit Fox pair members shared the same den 51% of the time. It is possible that we underestimated the rate of den sharing. We believe that on occasion a radio-collared fox denned with adult foxes that were not radio-collared.

In conclusion, we were able to describe Swift Fox den use patterns in northwest Texas even though we did not observe an effect of artificial dens. One possible reason for not observing an effect may be the low sample sizes. Even though we captured 55 Swift Foxes during our study, residents were not abundant as data analysis was only performed on eight Swift Foxes in treated and four Swift Foxes in untreated areas that were monitored ≥8 months per year. Also, no observed effect of artificial dens may be due to the fact that artificial dens were designed for temporary escape from predators, specifically Coyotes, while Swift Foxes were away from their natural dens. As part of the larger study mentioned before (McGee 2005), we found higher annual Swift Fox survival ($P = 0.07$) in artificial den treated areas (0.81) than in untreated areas (0.52) on the same study site. Higher survival in treated areas suggests that Swift Foxes were using artificial dens for escape during their normal nocturnal activities. Diurnal use of artificial dens was limited. We only tracked Swift Foxes to artificial escape dens on four occasions during the day. Therefore, alternative artificial den designs need further study to find a more suitable diurnal artificial den for Swift Foxes.

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Flowering During January in Antigonish County, Nova Scotia*

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Over 85 records of 23 species of blooming, herbaceous angiosperms were made at 19 sites in Antigonish County between 7 and 21 January 2006, when daytime temperatures reached 15°C. These observations followed an unusually warm fall and early winter. All species were observed on waste ground or in fields and garden plots, except for *Epigaea repens* L. which was part of ground vegetation in a sparsely wooded site. The primary families represented were Asteraceae (six species), Brassicaceae (six species) and Carophyllaceae (four species). The most commonly observed plants were *Taraxacum officinale* (L.) Weber (11 sites), *Capsella bursa-pastoris* (L.) Medik. (nine sites), *Thlaspi arvense* L. (three sites) and *Stellaria media* (L.) Vill. (four sites). Many plants and inflorescences were conspicuously frost-damaged, and flowers were rarely fully open. In several species, e.g., *T. arvense* and *Cerastium vulgatum* L., many individual plants looked normal and there was no evidence of frost damage. These observations are the latest flowering records for Nova Scotia.

Key Words: Asteraceae, Brassicaceae, Caryophyllaceae, winter flowering, phenology, Antigonish County, Nova Scotia.

In Nova Scotia most species of flowering plants have ceased to flower by early November (Zinck 1998). Taylor and Garbary (2003) carried out an extensive survey of flowering during an unusually warm late fall in Antigonish County and found 92 species in bloom during November-December. These were the latest flowering records of all but one of these species, and extended the known flowering periods for plants in Nova Scotia by an average of 45 days. Of particular note were 15 species that were in bloom on 14-16 December 2001.

A detailed evaluation of the phenology of the entire late fall flora was again undertaken in 2005 after another warm fall in which abundant flowering was still occurring in early November. This study will be described elsewhere in the context of regional climate change (Garbary et al.). Here, we provide records of 23 species of herbaceous plants observed in flower during an extraordinary warm period in January 2006. Our observations complement those on spring phenology by Vasseur et al. (2001). They compared flowering times in 12 species in the late 1990s with dates a century earlier and showed significant changes in only two species, of which only *Syringa vulgaris* L. had earlier flowering.

Materials and Methods

Collection sites

Nineteen sites in Antigonish Town and County, northern Nova Scotia, were explored between 7 and 21 January 2006 in three collection periods. Adjacent sites were a minimum of 200 m apart, and the maximum distance between two sites was 23 km. Ten sites were visited on 7 January, 16 sites during the period 11-16 January, and seven sites on 21 January. Five sites were visited three times, and three other sites were visited twice. Most of these sites had been previously visited by Taylor and Garbary (2003). Sites were typically highly disturbed areas of waste ground or gravel (Figure 1), or agricultural fields or garden plots. Each site was surveyed for 15-45 minutes. Notes were taken on the flowering status and plant condition of each species in bloom. Representative plants were collected; plants with cryptic flowers were dissected and examined under a stereomicroscope to ensure that flowers were intact. Voucher specimens for most species were prepared and deposited at St. Francis Xavier University. Nomenclature follows Zinck (1998).

Weather

Weather data were taken from the nearest active Environment Canada meteorological station at Tracadie, approximately 25 km from Antigonish (http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html). The first collecting period was on 7 January when daytime temperatures reached 4.3°C. This followed several days with daily maximum temperatures above 0°C and daily minimal temperatures no lower than -2.5°C. Each of the succeeding four nights had frost, although daytime maxima were always above freezing. The second collecting period, between 12 to 16 January, had minimum and maximum temperatures of 0.4°C and 15.9°C, respectively. Temperatures between 15 to 20 January were cooler and frosts occurred most nights (minimum -6.8°C) although mean daily temperatures were below freezing on only one day (-4.6°C). The final collecting day was 21 January when temperature ranged from 2.0 to 8.4°C. This was followed by at least ten days when temperatures dropped below freezing (-0.3 to -9.2°C) and conditions were more typical of the season.

FIGURE 1. Sample habitat. Waste ground on campus of St. Francis Xavier University adjacent to Trans-Canada Highway. 7 January 2006. Four species were found in flower at this site.

Results

ASTERACEAE

Taraxacum officinale (L.) Weber was the most widely distributed species, occurring at ten sites. One to four plants were observed at each site during all three collecting periods and blossoms occurred at two sites on 21 January. Each plant had one or two ragged inflorescences with short pedicels. Leaves had some frost damage and were often flattened against the substratum, although they had good colour on some individuals.

Achillea millefolium L. occurred as a single plant in a farmer's field and as six plants on waste ground (Figure 2). Plants had green leaves, but the flowering shoots were often reclining, with several to dozens of white florets. The flowering shoots observed 14 January were wilted and most of the flowers had turned brown.

Two species of *Matricaria* were found: *M. maritima* L. and *M. matricarioides* (Less.) Porter. Plants of *M. maritima* were found at two sites. A single, well-developed inflorescence was found on 7 January as well as several partially intact flower heads. By 15 January remaining ray florets were mostly lost; however, the disc florets on many heads remained bright yellow. The plants were often partly wilted but the leaves had healthy colour. Up to three plants of *M. matricarioides* were found at each of three sites, and it was observed during the first two collecting periods. Inflorescences typically had a mixture of dull yellow and brownish florets. The plants appeared no less viable than others observed in early December.

Leontodon autumnalis L. occurred at two sites on 7 January where single individuals were found with only one or two wilted inflorescences on each plant. Basal rosettes had good colour but were slightly wilted. Examination of both sites one week later revealed no flowering individuals.

Two plants of *Senecio vulgaris* L. occurred at one site on waste ground; a single individual was found at a second site. Florets on most inflorescences had turned brown but several had bright yellow florets. Plants were a maximum of 10 cm in height and flowering was observed only in the first two observation periods.

FIGURE 2. *Achillea millefolium* photographed *in situ* on 7 January 2006 at site shown in Figure 1. Flowering shoot is about 30 cm tall.

BRASSICACEAE

Capsella bursa-pastoris (L.) Medik. was among the most common plants flowering in January. It occurred at nine sites with one to three plants per site. Flowering individuals were up to 30 cm tall and carried a few flowers at the apex of each plant. Leaves were typically green and healthy, although larger plants had generally become decumbent. During the second week, plants were mostly very small (5-10 cm high) with only a few florets. On 21 January flowers were found at two sites.

Thlaspi arvense L. was among the most robustly flowering species observed. The plants were erect, dark green and with prominent white flowers. *T. arvense* in flower was as common in January as in any previous collecting period, and flowers were found at one site on 21 January.

Raphanus raphanistrum L. occurred at two sites where there were typically many plants. The stems and leaves of these plants were badly wilted and reclining; however a few bright yellow florets and numerous clusters of buds remained intact at many apices on many plants. In the second week only a single, badly damaged plant was found at one site.

Cardamine pensylvanica Muhl. ex Willd. was the only species clearly protected by the heat shadow of a large building. Dozens of small, prostrate plants each with one to several flowers occurred in a flowerbed along the side of a large brick building. No decline in flowering was noted in the second week and flowers persisted to 21 January.

Erysimum cheiranthoides L. was found at two sites and only in the second week. Four large plants were found along a bare concrete foundation for a house. The surrounding lot supported numerous plants of this species but all had gone to seed. A second site had a few small individuals up to 5 cm tall. Both sites were covered with snow on 7 January and so were not examined until the second week.

A single plant of *Lepidium campestre* (L.) R. Br. was found 12 January on waste ground. The plant was about 20 cm tall and had two clusters of flowers with the most vigorous close to the ground and immersed in a cluster of leaves.

CARYOPHYLLACEAE

Stellaria media (L.) Vill. was found at two or three sites in all collecting periods (four sites overall), and was among the most prominent of the plants in flower. At two locations it was found as scattered individual plants; however, at two other sites it formed large expanses of continuous ground cover with numerous inflorescences (Figure 3).

FIGURE 3. *Stellaria media* photographed *in situ* on 7 January 2006 showing part of a large colony about 1 m in diameter.

Flowering individuals of *Cerastium vulgatum* L. were few and occurred at only three sites, although many vegetative plants or plants with remains of inflorescences were present at most locations. The reproductive individuals appeared healthy and showed no signs of frost damage. They grew on loose gravel where there was no competition from surrounding vegetation. Flowering persisted at one site to 21 January.

A few flowers were present on several plants of *Spergula arvensis* L. from a farmer's field in the first two weeks. The plants showed considerable frost damage and dissection showed that very few bore intact stamens and pistils. At a second site where vegetative parts of the plants were less damaged, no intact flowers occurred.

An extensive patch of *Spergularia rubra* (L.) J. & C. Presl. occurred on waste ground. The prostrate plants were 5-10 cm diameter and showed all reproductive stages from buds to fruits. The site was only examined during the second week of observation.

OTHER FAMILIES

Euphorbia helioscopa L. (Euphorbiaceae) was present at only one of the sites. There were hundreds of individuals. Large plants (20-40 cm tall) were con-

spicuously frost damaged, with the wilted stems causing the upper parts of the plants to topple over. The terminal portions of these plants looked healthy, and subsequent dissection of inflorescences showed intact flowers. Small plants (5-15 cm tall) showed less collapse of the stems and also had numerous intact flowers. Flowering persisted until 21 January.

Individual plants of *Fumaria officinalis* L. (Fumariaceae) were found on each of the first two visits to one site. The plants had two small inflorescences in which a few flowers still retained their characteristic two-toned colour. Inflorescences on other plants at this site had been severely damaged and turned brown. On most individuals the finely dissected leaves and delicate stems showed no conspicuous wilting. At another site dozens of plants grew in soil mounds, but there were no inflorescences.

Viola tricolor L. (Violaceae) occurred at two sites. Both were in flower beds and one was adjacent to a building. Plants at both sites had leaves and stems in excellent condition and several to dozens of fully open flowers with blossoms persisting until 21 January.

There were numerous plants of *Veronica persica* Poir. (Scrophulariaceae) at one site where they grew as prostrate clumps or straggling plants over the bare soil. The bilobed fruits were conspicuous, and a single intact but only partially open flower was found on single individuals returned to the laboratory at each of the three visits.

Vegetative plants of *Polygonum arenastrum* Jord. ex Boreau (Polygonaceae) were common at most sites. Although most plants had conspicuous frost damage, a few plants had two to three white-tipped buds and open flowers that persisted until week two.

Epigaea repens L. (Ericaceae) was the only woodland plant found in the study. An extensive population occurred at one site (14 January) among other ground vegetation beneath an open, mixed forest growing on sandy soil. Although buds on many plants appeared swollen, only a single plant had open blossoms.

Discussion

That any plants should be flowering in January in northern Nova Scotia, much less 23 species, is remarkable. This late phenology may reflect the ability of plants to have late flowering strains (e.g., *Thlaspi arvense*, Warwick et al. 2002), or possibly reflect a western European origin where fall and early winter temperatures would be much milder. Zinck (1998) does not include December in the flowering periods of any of these species; November is included in the flowering periods only for *Capsella bursa-pastoris*, *Matricaria matricarioides*, *Senecio vulgaris*, *Stellaria media* and *Viola tricolor*. The region falls within plant hardiness zone 5B of Agriculture and Agri-Food Canada (http://sis.agr.gc.ca/cansis/nsdb/climate/hardiness/intro.html), in which harsh winters kill non-hardy species.

January is normally associated with severe winter weather; the 30-year daily average temperature at Collegeville (the nearest meteorological station for which climate normals are available) is –6.6°C, and the average minimum is –11.6°C. Winters here are among the coldest in the province (Davis and Browne 1997). About 50 cm of snow falls on average in January, and a heavy snowpack is common. Snowpack depths in a wooded area of the St. Francis Xavier University campus were 40-50 cm in mid-January every year but one in 1999-2005 (B. Taylor, unpublished data). In the single low-snow year, the weather was very cold and the ground was frozen.

The circumstances that led to plants blossoming in mid-January were more complex than an extended period of warm weather. While fall and early winter of 2005-2006 were unusually mild, there had been regular nights of frost since November and two major snowfalls (5 and 15 December) prior to the collection period. The sites were visited over the course of three weekends, and in the intervening periods there were frosts on most night at Tracadie. These plant species appear to be very resistant to short-term freezing, as long as warm temperatures return quickly. In addition, the most severe weather may have occurred when the plants were covered with 20 cm of snow from the 15 December snowstorm. The snow would have insulated the plants from the deep frosts, but it was subsequently washed away by heavy rain.

None of the plants in bloom was restricted to the first round of collecting; indeed, five species were found in bloom only in the second round and ten species had blossoms on 21 January. The two sites supporting *Erysimum cheiranthoides* were snow-covered on 7 January and the single specimen of *Lepidium campestre* found in week two may have been missed on the earlier visit to the site. Only one site visited in this study could be considered highly protected and influenced by radiant heat from a building, and *Cardamine pensylvanica* was the only species unique to this site. The remaining sites were exposed to ambient air temperatures and precipitation.

Nevertheless, even though plants in bloom were found at 17 sites in mid-January, this was not a conspicuous phenomenon; surveys of additional sites revealed no plants in blossom. The sites with plants in flower comprised highly specialized habitats mostly of limited extent: land cleared for development, margins of abandoned or active agricultural fields, garden plots and soil mounds. Even within these sites, most plants of many species reported here had entirely succumbed to the rigours of winter.

The plant species in bloom were not a cross-section of the provincial flora. Most of the species reported here are opportunistic, weedy species that thrive in highly disturbed habitats, including agricultural settings (e.g., *Raphanus raphanistrum* L., Warwick and Francis 2005). Indeed many of our sites had less than 50% cover of vegetation. In addition, all species observed in flower except *Epigaea repens*, *Cardamine pensylvanica* and *Cerastium vulgatum* are non-native

members of the flora (Zinck 1998). Most of these species are weeds that were introduced from Europe with grain. It would appear that the ability to tolerate harsh physical conditions (in contrast with competitive ability) extends to tolerance of harsh weather as well (Taylor and Garbary 2003).

Flowering in January in a cold climate would appear to be futile, and therefore likely of little evolutionary value. Excepting *Epigaea repens*, all of the species reported here are annuals or short-lived perennials (Zinck 1998). As early colonizers of disturbed ground, they would be adapted to growing and reproducing quickly in advance of competition from later species. It seems likely that these species are adapted to grow, flower and set seed as long as the weather permits (e.g., *Senecio vulgaris*, Robinson et al. 2003). This phenology contrasts with that of longer-lived perennials in which above-ground plant parts senesce in late autumn in anticipation of winter. The ruderal species observed here evidently lack this adaptation, presumably because either cold temperatures (annuals) or competition (perennials) normally curtails reproduction and kills the plant. Consequently, when those events are delayed, the plants have no physiological mechanism to end flowering, even when seed production may be impossible.

An important exception to the above is Pomquet Beach Provincial Park, an undisturbed, coastal site where *Epigaea repens* was part of a dense community of ground vegetation beneath a diffuse tree layer. Unlike the remaining fall-flowering species, *Epigaea repens* normally flowers in April and May (Zinck 1998), when it forms a conspicuous part of the spring-flowering flora. The plants in flower in January may be considered either a second, late-fall flowering, or an exceptionally early spring flowering. This phenomenon contrasts with the situation of the remaining species, in which normal late-fall flowering merely persisted for a long time. It is doubtful that new flowers were initiated among these species.

Epigaea repens was observed in flower in the Annapolis Valley, about 250 km southwest of our study area, in early November 2005 (N. Nickerson, Agriculture and Agri-Food Canada, Kentville, personal communication). Hence our flowering material from Antigonish County probably should be considered a further extension of a late fall return to flowering. The same probably applies to *Fumaria officinalis*, for which the latest flowering month given by Zinck (1998) is August. It would be of interest to determine details of plant phenology for *E. repens* and other species at the extreme southern tip of the province, where January mean temperate is only just below freezing (plant hardiness zone 6B; Davis and Browne 1997).

Changes in plant phenology are indicators of climate change and have been used as a proxy for temperature (Badeck et al. 2005; Menzel 2002; Sherry et al. 2007; Walther 2004). Consequently, the January flowering records reported here might be considered as evidence of regional climate warming. Thus, even if regional climate warming has not been demonstrated, the changes that we observed would be a natural consequence of such a warming trend.

Acknowledgments

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The Occurrence of Muskoxen, *Ovibos moschatus* in Labrador

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Muskoxen were first observed in Labrador in 1988 and have since been recorded at several locations in two separate river valleys in northern Labrador. The occurrence of Muskoxen in Labrador is attributed to the dispersal of captive releases from Québec in 1973 and 1983. Here we document observation records and examine the future management of the species in Labrador and speculate on its possible effect on this northern ecosystem.

Key Words: Muskox, *Ovibos moschatus*, range, distribution, management, Labrador, Québec.

The Muskox (*Ovibos moschatus*) is a relic from the Pleistocene and is native to northern Canada, northwestern Greenland, and the northern coast of Alaska (Banfield 1974; Reynolds 1988). The elimination of the species from Alaska and the reduction of Muskox numbers in Canada by the early 1900s resulted in efforts to introduce and restore populations in several arctic areas (Klein 1988; Reynolds 1988). At present, Muskox populations are experiencing a period of success, with high numbers throughout most of their range (Groves 1997). Muskox apparently did not colonize the Québec-Labrador peninsula after the last glaciation as no remains have been found at archaeological sites (Banfield 1975).

In 1967, 15 Muskoxen (12 females, 3 males) were captured near Eureka, Ellesmere Island (Centre D'Études Nordique 1981*), and brought to the Umingmaqautik farm, near Kuujjuaq in northern Québec (Figure 1) for Inuit to establish a Muskox farm, create employment, and build up a stock to introduce the species into northern Québec (Le Hénaff and Crête 1989; Nault et al. 1993). A project of raising the animals to collect their quviut (Muskox wool) was unsuccessful. Subsequently, from 1973 to 1983, 54 animals were released at three different locations in northern Québec (Le Hénaff and Crête 1989). The first release sites were located to the north of Kuujjuaq and to the southwest of Tasiujaq (Le Hénaff and Crête 1989). In 1983, Muskoxen were released east of Kuujjuaq near the outlet of the Whale River. The Umingmaqautik farm was closed in 1983 and the remaining animals were given to the St-Félicien and the Orsainville zoos in Québec (Jean and Rivard 2005*).

The introductions in Québec proved successful. In 1983 a total of 148 Muskoxen were counted and by 1986, with a finite rate of increase of 1.25, the population had increased to 290 animals. By 1986, individuals and mixed groups of Muskoxen had dispersed in all cardinal directions up to 650 km from the original release sites throughout the province of Québec (Le Hénaff and Crête 1989).

In 2003, the Muskox population around Kuujjuaq and Tasiujaq was estimated to be 1400 animals, including calves (Jean and Rivard 2005*). In June 2005, aerial surveys on Diana Island, near Quaqtaq, counted a total of 112 adults and 25 calves. This new population apparently originated from the Tasiujaq area (Jean and Rivard 2005*).

Study Area

Over the past two decades, Muskoxen have been observed on several occasions in the Low Arctic Alpine-Torngat ecoregion in northern Labrador. This ecoregion has short, cool summers and long, cold winters with mean average daily temperatures ranging from -19 to -22°C in February and 7 to 9°C in July. Average annual precipitation is 500 to 700 mm with a total average snowfall of 3 m (Meades 1990*). The vegetation is tundra (Alpine heath) with sedge meadows dominating plateaus and Mountain Alder (*Alnus crispa*) and willow (*Salix* spp.) thickets dominating on the lower slopes and river valley slopes. Groves of White Birch (*Betula papyrifera*) and Balsam Poplar (*Populus balsamifera*) occur sporadically in some river valleys. Graminoids occur on the valley bottoms but are sparse to absent on the upper slopes and at high elevations. Dwarf Birch (*B. glandulosa*), Labrador Tea (*Ledum groenlandicum*) and Black Crowberry (*Empetrum nigrum*) dominate drier mountain ridges. Conifer trees are absent from this region (Meades 1990*). Major features of the terrain include braided east-flowing rivers, foothills, elevated plateaus, rugged coastal cliffs and inland mountains.

Methods

We recorded Muskox sightings during remote aerial field surveys in northern Labrador. We queried residents from remote communities throughout northern

Labrador and helicopter and fixed-wing aircraft pilots for sightings of Muskoxen. We found only one record of Muskoxen in other areas of Labrador apart from our own observations. We classified individual Muskox to age and sex from oblique aerial photographs. When possible, animals were classified as adult male or female, based on body size, coat color and size and shape of horns.

Observations

Five sightings of Muskoxen have been recorded in Labrador over the past two decades in three different river valleys, approximately 340 km apart. Four sightings were made from a helicopter in different years (1988, 1995, 2000, 2005) and included three sightings of a single Muskox, likely different animals, and one sighting of a group of three. The fifth sighting (2006 – 2008) was reported by residents of Nain while travelling by snowmobile to Voisey's Bay.

Site 1. Komaktorvik River Valley

The first sighting of Muskoxen in Labrador was recorded on 24 July 1988 at approximately 59°14'N, 63°56'W along the Komaktorvik River valley, which flows into Seven Islands Bay (Figure 1). Three individuals were observed in a large patch of willows (*Salix* spp.) in the river valley. All individuals had horns with a slight separation in the butte and were all approximately the same size indicating that these animals were likely adult males, although definite sex and age remain uncertain (J. Brazil, personal observation).

On 28 July 1995, one Muskox was again observed in the Komaktorvik River valley (59°14.65'N, 63°55.51'W) very near the original 1988 sighting. From a photograph, this animal, browsing in a large thicket of willows (*Salix* spp.) along the north slope of the river valley, appeared to be an adult male.

On 30 July 2000, during aerial surveys for Harlequin Ducks (*Histrionicus histrionicus*) and Peregrine Falcons (*Falco peregrinus*), we observed and photographed a lone Muskox in Seven Islands Bay at (59°14.16'N, 63°57.66'W) 3 to 4 km west of the previous sightings in 1988 and 1995. This animal was large, had well formed horns, and light coloration on the back and saddle and was identified as a sub-adult male (Olesen and Thing 1989).

The sightings along the Komaktorvik River valley occurred approximately 250 km northeast of the release site at Whale River providing a straight-line rate of dispersion of 50 km/year. The most probable dispersion route was along the Koroc River valley, which traverses the Labrador Peninsula.

Site 2. Hebron Fiord

On 9 June 2004, a single Muskox was observed near the outlet of Hebron Fiord (58°03.82'N, 63°12.71'W) (Figure 1, Site 2). This animal was feeding in a thicket of alders (*Alnus* spp.) and Willows (*Salix* spp.) at the foot of a small plateau on the north side of Hebron Brook where it flows into Hebron Fiord. A photograph identified this animal as an adult male > 4 years old (D. Jean, personal communication). The straight-line dispersal from the Whale River release site was a distance of 220 km providing a rate of dispersion of approximately 11 km/year. The most probable route of dispersion was south along the George River valley and then the Tasirlaq River to Hebron Fiord.

Site 3. Voisey's Bay

In April 2006, the fifth Muskox reported in Labrador was observed on a small unnamed island south of Tabor Island in Voisey's Bay at approximately 54°20'N, 61°43'W (Figure 1, Site 3). This animal was readily identifiable as its right horn tip was broken at the curl. This 4-5 year old male has remained on the island and is in its second winter at this location. The straight-line dispersal from the Whale River release site is a distance of 400 km providing a rate of dispersion of approximately 17 km/year. The most probable route of dispersion was south along the George River valley and then along either the Fraser or Kogaluk river to Voisey's Bay.

Discussion

Muskoxen have successfully dispersed and colonized many remote regions of northern Québec. The dispersal of Muskoxen from Québec into Labrador may have been influenced by unoccupied habitat and lack of dispersal barriers.

No mixed-aged groups (the reproductive segment of the population) have been observed to date in Labrador. It is thus likely that the separate observations at Komaktorvik River valley, Hebron Fiord and Voisey's Bay are of different animals that immigrated to Labrador through separate overland routes and at different times. Based on the dispersion of Muskox south along the George River in Québec through 1986 (Le Hénaff and Crête 1989), it is possible that other individuals or groups have traveled eastward into Labrador as far south as Nain along the numerous river valleys extending inland.

Although Muskoxen and Caribou (*Rangifer tarandus*) are occasionally found together on the same vegetation type, caribou usually move through an area rapidly, feeding on willows and flowering forbs whereas Muskoxen are more sedentary and forage on sedges and grasses (Parker 1978). Abundance and distribution of Muskoxen on many of the islands of the High Arctic appear to be related to the abundance and distribution of sedge-producing meadows (Parker et al. 1975; Parker and Ross 1976).

Initial colonization by Muskox may be slow and sporadic consisting mainly of adult males (Le Hénaff and Crête 1989; Reynolds 1988). This may explain why reproductive, mixed-aged groups have do not appear to have been observed yet in Labrador. As Muskoxen had populated many remote regions of Québec in all cardinal directions north of 54°30'N latitude by 1986 (Le Hénaff and Crête 1989) and populations continue

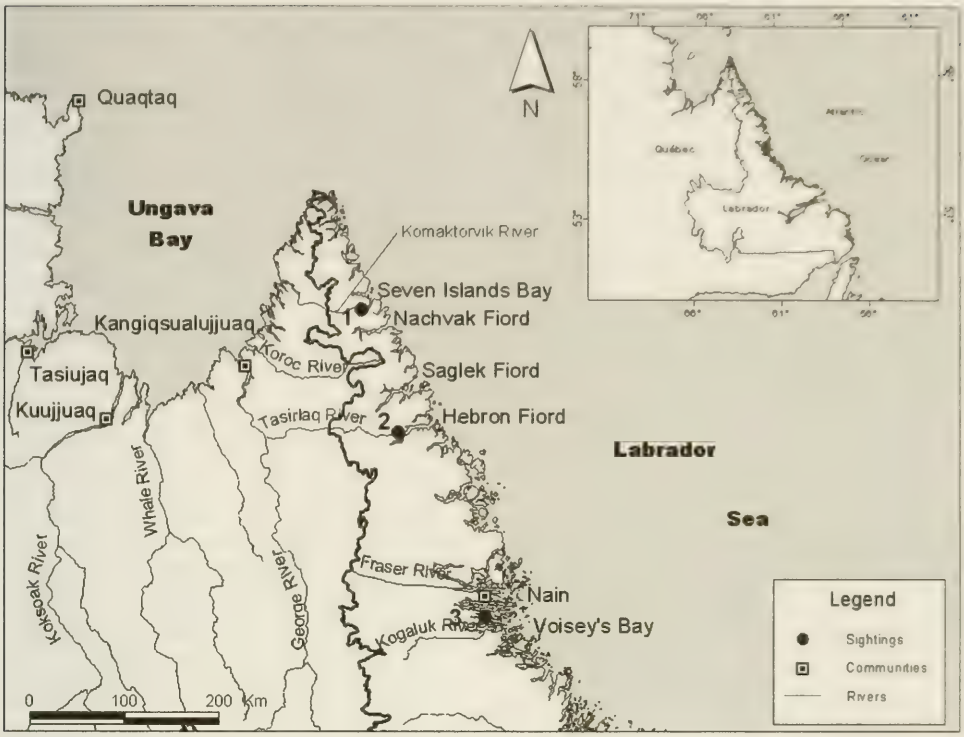

FIGURE 1. Location of Muskox (*Ovibos moschatus*) sightings in northern Labrador. The two release sites were near Tasiujaq and Kujjuaq in Québec.

to grow (lambda = 1.25) near their maximum finite rate of increase (1.30), breeding groups may have become established in Labrador but have gone undetected. Emigration of mixed-sexed groups out of regions first occupied may result in shifts in population distribution and range expansion (Reynolds 1988). The dispersal and colonization of Muskoxen to adjacent ranges can be slow. However, with the present high rate of population increase (Jean et al. 2004*) in northern Québec, we believe that emigration may soon result in a shift in an expansion of the distribution and range of Muskoxen into Labrador. Reynolds (1988) identified three stages in the expansion of Muskox into new range: (1) slow growth following release (2) the irruptive phase and (3) decline and stabilization. It is likely that in the next decade during the decline and stabilization of Muskox numbers in Québec that the dispersal of mixed groups into Labrador will occur and a breeding population be established.

In Alaska, where Muskoxen were extirpated and later reintroduced, range expansion occurred only over 20% of the former Muskox range and populations grew to fewer than 1000 individuals over nearly 30 years (Reynolds 1988).

Management Implications

Hunting of Muskox under a limited permit system is conducted on Nunivak and Nelson islands and in the Arctic National Wildlife Refuge of Alaska and in Nunavut, Northwest Territories, and Québec in Canada. Muskoxen are considered a unique and valuable trophy by the outfitting industry and Muskox meat is highly valued as an exported delicacy. This survivor of the ice ages is an important attraction for tourists, photographers, researchers and students of wildlife in areas where the species is endemic or introduced.

The establishment of a Muskox population in Labrador may provide an alternative to Caribou as a source of protein for northern communities as well as a new resource for developing the regional economy through sport hunting similar to northern Québec and Alaska (Le Hénaff and Crête 1989; Jean et al. 2004*; Reynolds 1988).

It appears that habitat for Muskoxen is widely distributed and largely unchanged in northern Labrador. With public support and proper management, Muskoxen may eventually become a more visible and familiar wildlife species in Labrador. We recommend that systematic aerial surveys be conducted to document the current and future status and distribution of Muskoxen in Labrador.

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The Spindle Tree, *Euonymus europaea* L. (Celastraceae): A Newly Naturalized Shrub in Nova Scotia

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Garbary, David J., and Amy E. Deveau. 2007. The Spindle Tree, *Euonymus europaea* L. (Celastraceae): a newly naturalized shrub in Nova Scotia. Canadian Field-Naturalist 121(1): 85-88.

Over 100 plants, including over 750 individual shoots, of *Euonymus europaea* L. are reported from the Town of Antigonish in northern Nova Scotia. Plants were found in five discrete areas separated by 200-1000 m. A few individuals at one site may represent human planting; however, over 90 % of plants occur on waste ground or in dense shrubbery where natural colonization has occurred. Many individuals were observed in fruit in the fall of 2005, and over 95% of the plants had well developed buds and flowers in May and early June 2006. *Euonymus europaea* is considered a newly naturalized species for the flora of Nova Scotia.

Key Words: Spindle Tree, *Euonymus europaea*, introductions, naturalized, Nova Scotia.

Euonymus (Celastraceae) is a cosmopolitan genus of over 200 species of vines, deciduous and evergreen shrubs, and small trees (Gleason and Cronquist 1991). Many species are ornamentals because of their colourful fruits and fall foliage and their unusual winged stems. At least six species are recorded from Canada, of which one is regarded as doubtful (Scoggan 1978; Catling 1997; Hinds 2000). Only *E. occidentalis* Nutt. ex Torr. (Western Wahoo), *E. atropurpurea* Jacq. (Eastern Wahoo) and *E. obovata* Nutt. (Running Strawberry-Bush) are native in Canada, with *E. occidentalis* restricted to the west coast. *Euonymus europaea* L., *E. fortunei* (Turcz.) Hand.-Mazz., *E. alata* (Thun.) Siebold, and *E. nana* Bieb. are escapes from cultivation in eastern Canada, although they have restricted distributions in New Brunswick (Catling 1997; Hinds 2000). Other species occur in the northeastern United States (i.e., *E. alata* and *E. americana* L., Gleason and Cronquist 1991). No species is included in the flora of Nova Scotia (Zinck 1998).

Euonymus europaea was first noted in Antigonish as a single, non-cultivated plant in 2001 in Antigonish County, Nova Scotia (DJG unpublished). In a subsequent survey during fall and early winter of 2005-2006 (Garbary and Taylor 2007), fruiting plants of *E. europaea* were noted from the previously recognized site as well as additional sites in Antigonish. The species likely represents an escape from cultivation. Here we report *E. europaea* as a newly naturalized plant in Nova Scotia.

Materials and Methods

During the course of plant surveys in late fall and early winter of 2001 and 2005-06 (Taylor and Garbary 2003; Garbary and Taylor 2007), fruiting specimens of *Euonymus europaea* were noted. In May 2006, when flower buds were well developed but unopened, a survey of all previously identified locations was undertaken. Further surveys were conducted to determine the size of the overall population in Antigonish and the extent to which the species was reproducing. The four primary sites are designated as University, Claymore, Hospital, and Brierly Brook (see Table 1). Two additional sites with only 1-2 primary plants were found but are not included in Table 1.

Sites were surveyed with hand-held GPS units (Garmin 12, Olathe, Kansas, USA). The largest stem in any cluster was considered the primary plant, and adjacent shoots were assumed to be derived from the same base, or progeny from seed. The height of the largest plant at each site was measured with a meter stick, and the numbers of subsidiary shoots and nearby juveniles were counted. These data were gathered to demonstrate that plants were successfully reproducing in the area. For each primary plant, the slope, exposure to full sunlight, proximity to water (ditches, ponds or saturated soil) and reproductive condition were recorded. The number of flower buds on each peduncle was counted on the population on St. Francis Xavier University. Voucher specimens are deposited in the herbarium of St. Francis Xavier University (STFX) with duplicates deposited in herbariums of ACAD (Acadia University) and NSPM (Nova Scotia Provincial Museum).

Results

With its opposite leaves on short petioles, the longitudinal whitish markings on many young stems that often gives them a four-angled outline, and the brilliant scarlet and orange fruits, *Euonymus europaea* is a distinctive species during all seasons (Figure 1).

Most primary shoots (> 95%) and many adjacent smaller plants had abundant clusters of flower buds in mid- to late May 2006. The bud scales of branch buds and developing inflorescences had red tips and a ciliate

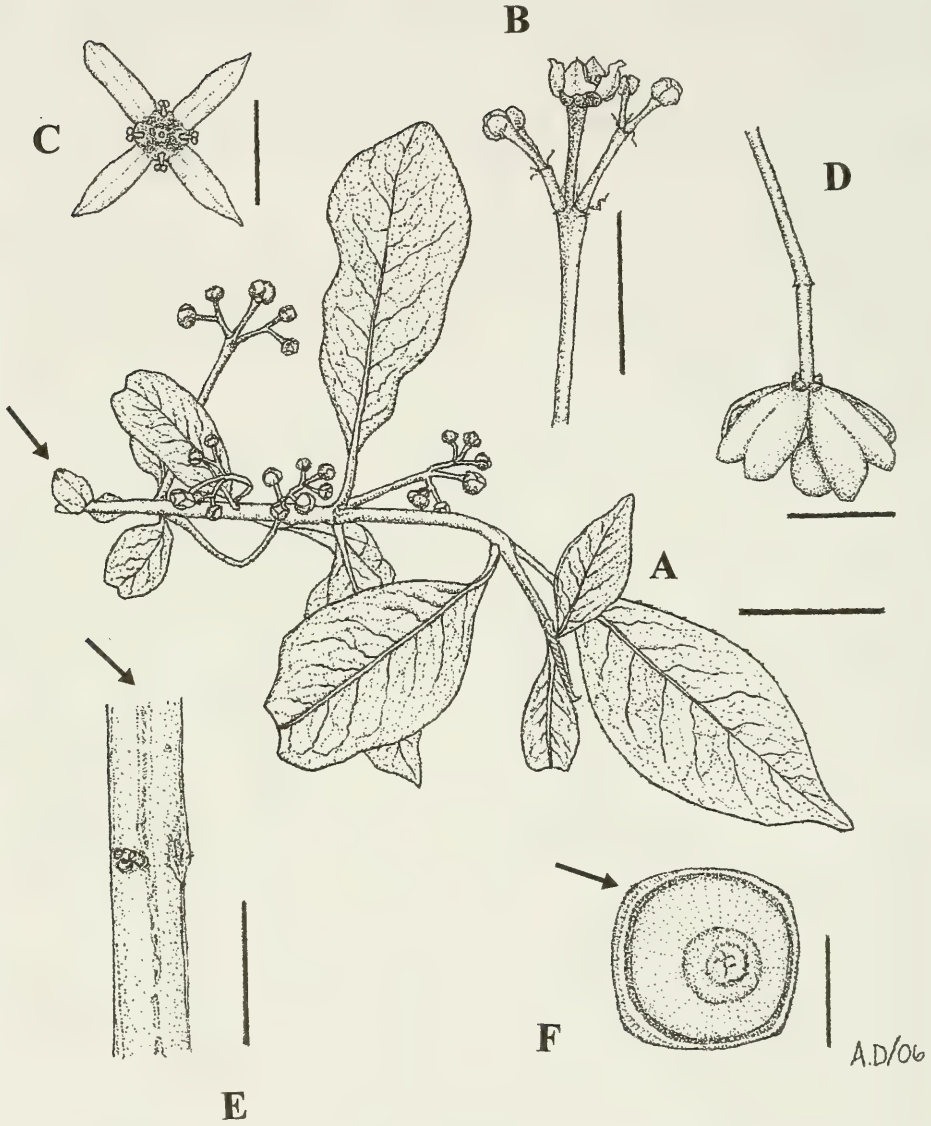

FIGURE 1. *Euonymus europaea* from Antigonish. A) Branch with leaves, developing inflorescences and bud scale (arrow). Scale = 2 cm. B) Inflorescence with central bud partially open. Scale = 1 cm. C) Fully open flower. Scale = 5 mm. D) Mature fruit after dehiscence showing single seed. Scale = 1 cm. E) Longitudinal view of stem showing leaf scar and longitudinal ridge on bark (arrow). Scale = 2 cm. F) Transverse section of stem showing squarish outline and position of longitudinal ridges. Scale = 5 mm.

margin. Flowers did not open until late May when a single bud in each peduncle opened. The flowers are not conspicuous, and plants are cryptic against a background of the larger and showier species of *Prunus*, *Crataegus* and *Amelanchier*. The flowers are ca. 1 cm diameter, and have diagnostic greenish-white petals. The flowering peduncles had from 1-9 buds (5.0 ± 1.8), with most inflorescences having odd numbers of buds.

Over 100 primary plants over 50 cm high and over 650 secondary shoots and adjacent progeny were found at six locations in Antigonish (Table 1). The primary axes were 1.5 ± 0.8 m (mean ± s.d.) tall, and many plants were over 3 m (Figure 2) with a trunk diameter of up to 6 cm. There was wide variation (0 – >50) in number of secondary shoots and progeny associated with each primary plant, although about 30% had

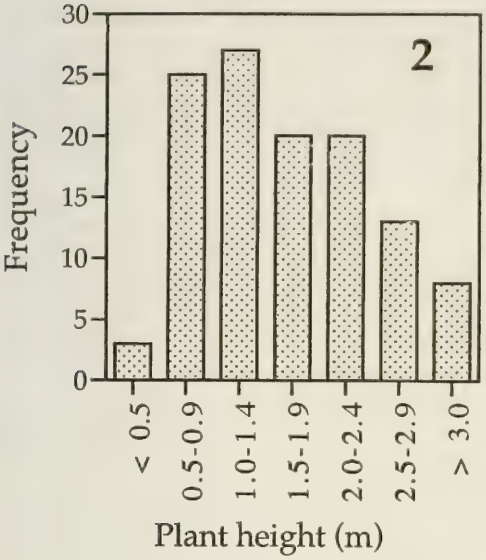

FIGURE 2. Histogram showing sizes of 112 primary stems of *Euonymus europaea* from Antigonish.

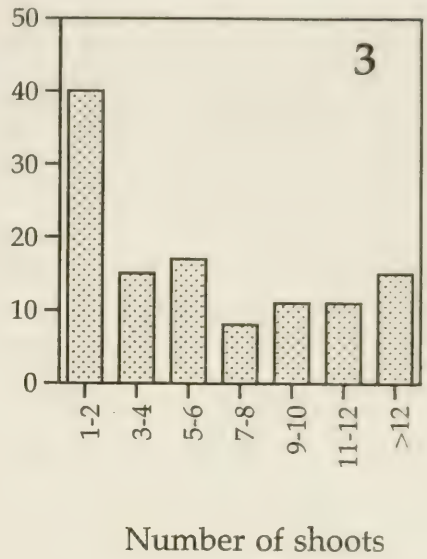

FIGURE 3. Histogram showing number of secondary shoots and possible progeny associated with each primary plant.

only 1-2 additional axes (Figure 3). The largest single clump was at the Brierly Brook site. It occupied about 4 × 3 m and had about 50 separate stems that formed a dense thicket.

Plants were typically found in the open where they experienced full sun, or at the edges of dense shrub thickets where they were either crowded or overtopped by the surrounding plants. Most plants grew in moist locations. Plants in the open tended to occur on boggy ground, and plants were common close to ditches, ponds or small pools or on the flood plain of a stream. Some plants were present on steep slopes on ground with obvious seeps. Only a few plants occurred on drier soils; these were in grass on mowed areas and may have been planted.

Discussion

All of the *Euonymus* plants we observed were *E. europaea*. The plants are scattered over several square kilometres in at least five separate sites. The abundance of small plants within 3 m of larger individuals and widely scattered small plants (i.e., less than 1 m) show that successful seed germination is occurring. These observations are consistent with the definition of naturalized of Pysek et al. (2004); i.e., that successful reproduction has been occurring for at least ten years in the vicinity of the parent plant.

The site where most of the plants were found is an open field where *E. europaea* is mixed with many other shrubs. These shrubs are mostly widely scattered and

TABLE 1. Populations of *Euonymus europaea* in Antigonish. Additional sites with only one or two primary plants not included in the table.

	Hospital	Claymore	Brierly Brook	University
Latitude and longitude	45°37.743'N 61°59.033'W	45°37.056'N 61°58.877'W	45°37.394'N 61°59.179'W	45°37.074'N 61°59.182'W
Number of primary plants	12	4	5	90
Secondary shoots and juveniles	61	11	95	683
Number with flower buds	11/12	4/4	5/5	87/90
Habitats	Steep slope with extensive bed of lupins; mowed and unmowed grassy area	Shrub thicket beside small stream	Border of hayfield at margin of thicket adjoining stream	Open areas with herbaceous plants and shrubs; on flat ground to steep slopes
Shade	Full sun	Partial to heavy shade	Partial to high shade	Full sun but some heavily shaded

have an overall cover of less that 15%. The occasional individuals that we observed in dense shrubbery had few secondary shoots. Thus, once vegetation closes in, *E. europaea* may not be able to establish or spread. Species with fleshy fruits have low ability to recruit under a canopy of *E. europaea* relative to nine other tall shrub species (Kollmann and Grubb 1999). This has not yet become important in Antigonish, since we have observed only one continuous canopy of *E. europaea.*

Some *Euonymus* species, including *E. alata,* have become invasive in several northeastern and midwestern states (e.g., http://tncweeds.ucdavis.edu/alert/alrteuon.html) following escape from ornamental plantings. *E. alata* is considered a threat in woodland areas, fields and coastal scrubland, where it can outcompete native species. There is no record of *E. europaea* as a problematic invasive species, although it has become widely naturalized in central Canada. Montgomery (1957) refers to sites where it has become "very common" in woods. The abundance of mature and immature individuals in Antigonish suggests that this is possible for *E. europaea* in Nova Scotia. The extensive field survey carried out by DJG in the fall and early winter of 2005-2006 identified four of the sites reported here. Additional surveys in 2006-2007 did not reveal further populations. While there are no specimens based on wild collections of *E. europaea* in other local herbaria (i.e., NSPM, ACAD, NSAC [Nova Scotia Agriculture Canada]), other urban areas may be expected to host wild plants (e.g., Wolfville, Nova Scotia – Sam Vander Kloet, personal communication). To satisfy the Pysek et al. (2004) definition of invasive, many offspring must be produced at a distance from the parent individuals. The limited dispersal of *E. europaeus* in Antigonish has not yet satisfied this criterion.

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Notes

Serviceberry, *Amelanchier intermedia*, Escaped from Cultivation in Eastern Ontario

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Catling, Paul M., and Gisele Mitrow. 2007. Serviceberry, *Amelanchier intermedia*, escaped from cultivation in eastern Ontario. Canadian Field-Naturalist 121(1): 89–91.

Although not generally recognized as a cultivated plant, *Amelanchier intermedia* is widely cultivated in eastern Ontario under the incorrect name, *A. canadensis*. Wild plants referable to *A. intermedia* in old fields south of Ottawa are likely to be escaped from cultivation. *Amelanchier intermedia* likely originated as a hybrid involving *A. canadensis* and *A. laevis*. A key to the Canadian species of *Amelanchier* with glabrous ovaries is provided.

Key Words: Saskatoon, Juneberry, Serviceberry, Shadbush, *Amelanchier intermedia*, status, cultivation, hybrid, Ontario.

Fernald (1950) and Kartesz and Meachum (1999) reported *Amelanchier intermedia* Spach from Newfoundland to Minnesota and south to North Carolina. It was not included in Michigan by Voss (1985), but Cinq-Mars (1971) showed a relatively extensive distribution in southern Quebec. Although within the general range outlined by Fernald (1950) and frequent in adjacent Quebec (Cinq-Mars 1971), *A. intermedia* was not reported in Ontario by Soper and Heimburger (1982) or McKay (1973). Although it was listed for Ontario by Newmaster et al. (1998*), the listing was without ranking indicating a lack of information on its status. Over several years of examining populations of *Amelanchier* in Ontario we have found plants that correspond to the description of *A. intermedia* at only two locations in old field habitats south of Ottawa. Plants similar to these wild plants are widely cultivated but are never called *A. intermedia*.

Most eastern Ontario nurseries offering shrubs for sale offer Serviceberry (also called Juneberry, Shadbush and Saskatoon, *Amelanchier* spp.). The plants that are most frequently available are either multi-stemmed shrubs labelled as *A. canadensis* or they are named cultivars referable to *A.* ×*grandiflora* Rehder, a hybrid of *A. arborea* (Michx. f.) Fern. and *A. laevis* Wieg. The plants referred to as *Amelanchier canadensis* (L.) Medic. are particularly popular with companies providing landscaping for office buildings, whereas the larger small trees are increasingly popular for use as street trees under utility wires (Gerhold 1999).

Identification of wild and similar cultivated plants

With petals 9–13 mm long and reddish-tinged leaves prominently acute at the tip, the plants growing in old fields and woodland edges south of Ottawa (cited below) and similar plants labelled as *A. canadensis* in 10 local nurseries as well as many plants in Ottawa gardens could not be placed with *A. canadensis*, which has petals 3–10 mm long and green young leaves with leaf tips more or less rounded (Cruise 1964; Cinq-Mars 1971). They are not *A. laevis* because the leaves are tomentose at flowering instead of glabrous. Nor are they *A. arborea* because these are multi-branched shrubs with reddish-tinged leaves and flowers with a relatively broad hypanthium 4.5–5.5 mm across instead of single-trunked trees with green leaves and flowers with a relatively narrow hypanthium 2.5–3 mm across. They also differ from *A. arborea* in having sepals that are less reflexed and lanceolate with a concave outer edge instead of strongly reflexed at the base and oblong-lanceolate with the outer edge convex. In addition the berries of these shrubs are pleasant-tasting rather than insipid as in *A. arborea*. These plants do correspond to *A. intermedia* Spach of Fernald (1950) and Cinq-Mars (1971).

While it is clear that *A. intermedia* occurs both as a cultivated plant and outside of cultivation in eastern Ontario, it is not clear whether or not the wild plants are escapes from cultivation. It seems most likely that they are escaped since one of the parents, *A. canadensis*, does not occur in the local area and the similar widely cultivated plants have become increasingly popular over the past few decades and are currently widely available in nurseries and widely used by landscaping companies. A key to the group with glabrous ovaries is provided below.

Specimens referable to *A. intermedia* growing outside of cultivation in Ontario include: Ottawa-Carleton: open, sandy ground 3 km N of Herbert's Cor-

ners, Osgoode Twp., 45.2359°N, 75.5733°W, 17 May 2002, *P. M. Catling s. n.* (DAO); UNITED COUNTIES OF STORMONT, DUNDAS AND GLENGARRY: open old field, 2 km WNW of Ormond and about 5 km N of Winchester at 45.1552°N, 75.4173°W, 21 May 2005, *P. M. Catling 2005-41, 2005-42* (DAO). Cultivated specimens referable to *A. intermedia* collected as part of this study in Ottawa area gardens are also preserved in DAO (see DAO 798819, 801264, 801265, 801272, 801275, 801280, 801328, 801329, 801330, 801332) and vouchers obtained from nurseries are also in the collection (see DAO 800923, 800924, 800925, 801262, 801267, 801269, 801270, 801271, 801333, 801335).

Taxonomic history and possible hybrid origin of *A. intermedia*

Jones (1946) included the name *intermedia* with his relatively narrowly defined *A. canadensis* showing a largely eastern coastal plain distribution. Wiegand (1920) used the name to represent a species related to *A. canadensis* which he defined narrowly. Later Fernald (1950) expanded the concept to include plants clearly intermediate between *A. canadensis* and *A. laevis* and this concept was maintained in the classic work of Cinq-Mars (1971).

Amelanchier intermedia may have arisen as a hybrid of *A. canadensis* and *A. laevis* as noted by various authors (e.g., Gleason and Cronquist 1991). Plants referable to *A. intermedia* have leaves that are only moderately pubescent and losing their pubescence at flowering. This and their purplish tinge suggests that one parent is a species with leaves purple-green and glabrous and unfolded at flowering. The only species with a glabrous ovary fitting this description is *A. laevis*. The relatively short petal lengths and also the widely open hypanthium of the putative hybrids suggest that the other parent may have short petals, barely reflexed sepals and a saucer-shaped hypanthium. This is true of *A. canadensis* but not *A. arborea* which has relatively long petals, prominently reflexed sepals and a rather narrow, campanulate hypanthium. Furthermore a cross of *A. arborea* and *A. laevis* would be expected to produce a more tree-like hybrid, one form of which, *A.* ×*grandiflora* Rehd. is well known. Other species of *Amelanchier* have pubescent ovary summits and/or rounded and more coarsely toothed leaves and are thus excluded from consideration as putative parents. *Amelanchier canadensis* × *laevis* hybrids have been reported to be common in some areas, whereas hybrids of *A. arborea* and *A. canadensis* are less common (Cruise 1964).

The only material that can be confused with *Amelanchier interior* that occurs in the lower Ottawa valley are depauperate specimens of *A. arborea* which differ in their early flowering with unexpanded and very hairy leaves and apparent hybrids of *A. laevis* and *A.spicata* which differ in their broad spatulate petals and partially hairy ovaries. The typical habitat of these latter plants is dried and disturbed heath bogs where *A. spicata* also occurs. Such plants may have been the basis for reports of *A. intermedia* from edges of bogs in Minnesota (Nielsen 1939). Alternatively these reports may have been based on fruiting material of *A. interior* of the northwestern Great Lakes region which had lost some of the pubescence on the ovary (as found to be the case for reports of *A. intermedia* from northwestern Ontario). The following key will readily separate flowering *A. intermedia* from related Canadian species.

Key to Canadian flowering *Amelanchier* with glabrous ovaries:

1a. Leaves glabrous and purple at flowering; petals 10-20 mm long; lowest pedicels 25-50 mm long ..... *A. laevis*

1b. Leaves tardily pubescent and green or purple-tinged at flowering; petals 3-15 mm long; lowest pedicels 8-35 mm long 2

2a. Petals 3-10 mm long; leaves round-tipped ..... *A. canadensis*

2b. Petals 9-15 mm long; leaves pointed at tip 3

3a. Leaves purple-tinged, more or less expanded and becoming glabrous beneath during flowering; shrubs ..... *A. intermedia*

3b. Leaves green, small and folded at flowering, pubescent beneath after flowering; trees ... *A. arborea*

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A Freshwater Hydrobiid, cf. the Squat Duskysnail, *Lyogyrus granum* (Mollusca), Widespread in the Hampton Marsh, New Brunswick

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McAlpine, Donald F., Rachel H. Maillet, Andrew J. Albert, Laura M. Crossman, Rebecca R. Smith, and André Martel. 2007. A freshwater hydrobiid, cf. the Squat Duskysnail, *Lyogyrus granum* (Mollusca), widespread in the Hampton Marsh, New Brunswick. Canadian Field-Naturalist 121(1): 92-94.

In Canada, the Squat Duskysnail, *Lyogyrus granum,* is an apparently rare freshwater hydrobiid. We document putative *L. granum* to be widespread throughout the Hampton Marsh, New Brunswick, with densities sometimes exceeding 150 snails/m^2 on substrates ranging from vegetated organic detritus over mud, to sparsely-vegetated cobble/sand lakeshore. That our identification of *L. granum* from Hampton Marsh remains tentative, in spite of large samples, emphasizes the need for detailed taxonomic study of any putative *L. granum* populations in Canada. Such study will be necessary before the true conservation status can be determined for this and any related taxa, as yet unrecognized in Canadian material.

Key Words: Squat Duskysnail, *Lyogyrus granum,* Hydrobiidae, conservation status, New Brunswick.

Of the two species of freshwater hydrobiid snails recorded in Maritime Canada (Clarke 1981), the Ordinary Spire Snail, *Amnicola limosa*, and the Squat Duskysnail, *Lyogyrus granum*, the latter is very poorly known. In part, this is due to difficulties in identification; Smith (1991) notes that in Massachusetts *L. granum* and *L. pupoidea* will rarely be confidently distinguished from each other and Jokinen (1992) has reported sexual dimorphism within the genus that is poorly understood.

In Canada, *L. granum* has been reported from only two locations in south-central New Brunswick (Jemseg and Baker Brook) and 11 sites in Nova Scotia (COSEWIC 2003*). COSEWIC (2003*) suggested that *L. granum* is rare in Canada and that the only known Canadian populations in New Brunswick and Nova Scotia should be considered nationally significant. Nonetheless, a paucity of information on this species has led to a designation of Data Deficient by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Here we document a *L. granum*-like hydrobiid to be abundant and widespread in the Hampton Marsh, New Brunswick.

Considered one of the largest and most diverse freshwater marshes in the Saint John River floodplain, the 2000 hectare Hampton Marsh (45°33'N, 65°50'W) consists of a series of eutrophic oxbows, tributaries and backwaters of the Kennebecasis and Hammond Rivers. The marsh has repeatedly been identified as a site of ecological importance within the province (Stocek 1984*; Dionne et al. 1988; Austin-Smith 1994*) and is currently designated as a wetland of significance by the Wetlands and Coastal Habitat Program of the New Brunswick Department of Natural Resources and Energy. Although about 40% of the land adjacent to the marsh remains forested (Austin-Smith 1994*), shoreline development, sedimentation, eutrophication, and pesticide introduction from upstream agricultural areas are issues of concern. The marsh is located largely within the municipal boundaries of Hampton and Quispamsis, two of the fastest growing urban areas in New Brunswick, and the Local Service District of Nauwigewauk (Austin-Smith 1994*).

Putative *L. granum* were discovered in the Hampton Marsh during the course of ongoing mollusc surveys on the lower Saint John River and tributaries (Sabine et al. 2004; McAlpine et al. 2005). Data reported here were collected from 20 June to 22 August 2005 from 25 survey sites scattered across the marsh. Survey sites had been selected based on study of aerial photos, topographic and nautical maps, and field inspection, to represent a variety of habitat types (i.e., lakeshore, river channel, backwaters, oxbows) within the marsh complex. Molluscs were collected using a combination of techniques that included SCUBA, snorkeling, dip netting, and sieving bottom sediments; voucher material of all mollusc species reported here has been placed in the New Brunswick Museum mollusc collection. To provide abundance estimates for putative *L. granum* in contrasting habitats within the marsh, 15 0.25-m^2 random quadrats were also sampled in ~ 1 m of water in August at three of the sites. Only live snails were tabulated in quadrats following the complete removal, sieving, and hand-sorting of the top 5 cm of sediment along with all aquatic vegetation. Hampton Marsh specimens of *Lyogyrus* were identified largely on the basis of the structure of the verge in fresh material as described and illustrated in Smith (1991) and Jokinen (1992), but reference was also made to shell and opercular morphology as noted by these authors, and by Clarke (1981). As well, comparison was made with Atlantic Canadian material in the collection of the Canadian Museum of Nature. Although *L. pupoidea* has not been recorded in Canada, our extensive series of specimens agree with Smith (1991), in that intermediates and extremes showing external morpholog-

TABLE 1. Densities of putative *Lyogyrus granum* in contrasting habitats in the Hampton Marsh, New Brunswick.

GPS	Habitat	Mean ± sd(/m²)	Range (/m²)	Associated molluscs[1]
N 45° 30.025' W 65° 52.50'	rocky lakeshore,	96.8 ± 52.6	48-184	Ai, Al, Cd, Ec, Gd, Ha, Lr, Pc, Ph, Sc, Se, Vt.
N 45° 31.358' W 65° 52.867'	clearwater *Ceratophyllum* marsh	76.0 ± 63.9	4-160	Ai, Al, Ec, Gd, Ha, Pa, Ph, Se, Ss, Vs, Vt
N 45° 31.856' W 65° 51.297'	murky backwater channel	17.6 ± 12.5	8-20	Al, Cd, Ec, Fp, Gd, Pc, Ph, Se, Ss, Vs, Vt

[1] Ai=*Anodonta implicata*, Al=*Amnicola limosa*, Cd=*Campeloma decisum*, Ec=*Elliptio complanata*, Fp=*Ferrissia parallela*, Gd=*Gyraulus deflectus*, Ha=*Helisoma anceps*, Pa=*Planorbella campanulata*, Lr=*Lampsilis radiata*, Pc=*Pyganodon cataracta*, Ph=*Physa heterostropha*, Ss=Sphaeriidae sp., Sc=*Stagnicola catascopium*, Se=*Stagnicola elodes*, Vs=*Valvata sincera*, Vt=*Valvata tricarinata*

ical features of *L. pupoidea* are present. COSEWIC (2003*) notes the possibility of *L. pupoidea*, as well as closely related *L. browni*, overlapping the Canadian range for *L. granum*. Clearly there is a need for detailed taxonomic study of any putative *L. granum* populations in Canada before the true distribution and conservation status of this and related species in the country can be determined.

Putative *L. granum* are widespread throughout the Hampton Marsh, although they were noticeably absent from sites in the river channel, where currents of 0.1-0.3 m/sec were recorded, and in the lowest portion of the marsh where there is periodic intrusion of brackish water. Discounting two sites where brackish water clearly intrudes on occasion, we recorded *L. granum* at 17 of the 22 survey sites remaining. The limited habitat data available for *Lyogyrus* indicates that this species is generally found on organic debris and vegetation in standing water (Clarke 1981; Smith 1987*; Jokinen 1983). Currents at sites where we recorded *Lyogyrus* did not exceed 0.1 m/sec. COSEWIC (2003*) reports *L. granum* densities of up to 400/m²; densities in the Hampton Marsh were lower but sometimes exceeded 150/m² (Table 1). We found the highest densities along an open, sparsely-vegetated cobble/sand lake shore on rocks and on the living shells of the unionids *Elliptio complanata*, *Anodonta implicata* and *Lampsilis radiata*. *Lyogyrus granum* was also abundant in clear water on submersed vegetation where *Ceratophyllum demersum* dominated (lakeshore vs clear water; Mann-Whitney $U = 15$, $P > 0.05$) but significantly less abundant in a murky vegetation-clogged backwater channel characterized by *Vallisneria americana* and *Potamogeton perfoliatus* than on the rocky lake shore (lake shore vs backwater; Mann-Whitney $U = 25$, $P < 0.05$) (Table 1). Both of the more heavily vegetated sites were characterized by deep bottom layers of organic detritus over mud.

COSEWIC (2003*) suggests that the few sites from which the species has been recorded in Canada indicate either that *L. granum* is a habitat specialist, that human impacts are reducing the availability of suitable habitat, that *L. granum* is a truly rare species, or some combination of these factors. That the rarity of this species may only be apparent, due to a lack of collecting, is not mentioned. Jokinen (1983, 1992) found this snail to be uncommon in Connecticut, and both Smith (1987*) and Jokinen (1992) found the species to be rare in Massachusetts and New York, respectively. While *L. granum* may indeed prove to be naturally rare, this species is small and easily overlooked and there have been few detailed surveys of the freshwater gastropods of Atlantic Canada. That *L. granum* has been recorded from 11 widely distributed sites across Nova Scotia also suggests that further field investigation may show this species, in association with related taxa as yet unrecognized in Canada, to be more prevalent in the region than current records indicate.

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Northern Range Extension of the Pygmy Shrew, *Sorex hoyi*, in the Yukon

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A Pygmy Shrew, *Sorex hoyi*, was captured in a pitfall trap on the Blackstone River (65°04.6'N, 138°10.8'W) in central Yukon. This represents a northern range extension of about 110 km for *S. hoyi* in the Yukon.

Key Words: Distribution, Pygmy Shrew, *Sorex hoyi*, Yukon.

Shrews, *Sorex*, have been undersampled in northwestern North America because they are often not the focus of surveys (Jarrell 1986; Nagorsen 1996) and they are not readily captured in traps designed for small rodents (Nagorsen 1996). As such, our knowledge of the distributions of shrews in northwestern North America (i.e., Alaska, Yukon, northern British Columbia, western Northwest Territories) is limited. In recent years, however, directed surveys of shrews in this vast region have resulted in discovery of a new species, the Alaskan Tiny Shrew, *Sorex yukonicus* (Dokuchaev 1997), and range extensions for a number of species (e.g., American Water Shrew, *S. palustris*, Jarrell 1986; Cook et al. 1997; Tundra Shrew, *S. tundrensis*, Nagorsen and Jones 1981; Alaskan Tiny Shrew, *S. yukonicus*, and Pygmy Shrew, *S. hoyi*, Peirce and Peirce 2000). Nevertheless, much work is needed to better understand the distributions of shrews in northwestern North America. Herein, we describe a northern range extension for *S. hoyi* in the Yukon.

During an extensive survey of the small mammal fauna along the Dempster Highway in central Yukon, a Pygmy Shrew was captured on 12 July 2005, 2 km west of the Blackstone River (65°04.6'N, 138°10.8'W), 129 km northeast of Dawson City. The shrew was captured in an unbaited pitfall trap installed flush with the substrate. Pitfall traps have been found to be particularly effective for Pygmy Shrews (Prince 1941). No other shrews were captured at this site. The specimen was identified using dental characteristics and keys in Nagorsen (2002) and van Zyll de Jong (1983). The specimen (Field ID: DEMP-0015) is held by the Yukon Department of Environment, but will be deposited at the Museum of Southwestern Biology.

Our record represents a northern range extension of approximately 110 km for *S. hoyi* in the Yukon. Youngman (1975) mapped the hypothetical range as being as far north as the Old Crow Flats (approximately 68°N). Prior to our capture, however, the northernmost specimen records of *S. hoyi* in the Yukon were from 22 km east of Dawson City (Youngman 1975; van Zyll de Jong 1983) and the abandoned village of Fortymile (64°25'N, 140°32'W), 67 km northwest of Dawson City (B. G. Slough and T. S. Jung, unpublished data).

This Yukon range extension of *S. hoyi* is not surprising as there are more than 125 specimens held at the University of Alaska Museum of the North that were collected north of 65°N in Alaska, with the most northerly taken near the Dalton Highway at the Dietrich River (67°37'N, 149°46.8'W; UAM 23050). In

addition, van Zyll de Jong (1983) reported specimens from Chick Lake and Fort Franklin, two locations north of 65°N in the Northwest Territories. It is likely that *S. hoyi* ranges further north in the Yukon; this is a species of the boreal forest and it likely extends north to the treeline. Further observations are needed to document the range of *S. hoyi* and other soricids in the Yukon and elsewhere in northwestern North America (Cook et al. 1997).

Acknowledgments

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A Tribute to Neal Philip Perry Simon 1973-2006

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Chubbs, Tony E., and Frank R. Phillips. 2006. A tribute to Neal Philip Perry Simon, 1973-2006. Canadian Field-Naturalist 121(1): 96–99.

Neal Philip Perry Simon, our friend, hunting companion, and colleague, was born in Labrador City, Newfoundland and Labrador, on Sunday 30 December 1973, to Dave and Doreen Simon. He passed away suddenly and unexpectedly in a tragic accident on 23 September 2006, at the age of 32 near Happy Valley – Goose Bay where he resided since 1988. His parents, Dave and Doreen Simon, sister Nicole and fiancée, Leanne Elson, survive him. Neal had a mutual adoration for his grandparents, Carrie and Gordon Templeman, who will miss him dearly.

Neal's early education was in Catholic schools: Notre Dame Academy (primary and elementary) and Labrador City Collegiate (high school) both of which were in Labrador City and have since closed. Neal, along with his grade school pal Colin Carroll, developed a keen interest in biology at an early age, trying his hand at taxidermy in grade seven. Francis Schwab, Neal's first year university professor, was instrumental in introducing him to scientific research, especially the effects of post-fire succession on songbird abundance. His post-secondary education began at Memorial University of Newfoundland in St. John's, Newfoundland and Labrador, where in 1995 he obtained a B.Sc.(Hons) with a major in ecology and evolution and a minor in statistics. It was there, under the instruction of Eric Baggs and the late Dr. Gary Cowen, he was instilled with an appreciation of the importance of small mammals in understanding forest structure dynamics.

In 1996, Neal began his Master of Science in Forestry at the University of New Brunswick under the supervision of Dr. A. W. Diamond. As part of the Atlantic Cooperative Wildlife Ecology Research Network (ACWERN), Neal regularly contributed presentations at the annual workshop from 1998 to 2003. In 2000, Neal continued under the supervision of Dr. Diamond to pursue his Ph.D. on the effects of site productivity and heterogeneity on bird habitat quality and species richness. His research ranged from modelling species distributions to studying the effects of landscape features on habitat use by passerines, with a focus on their demography. Much of Neal's work had an overlying conservation theme linked quite strongly to ecological theory. Neal completed his Ph.D. in 2005 and was about to embark on his post-doctoral research in the spring of 2007.

Neal taught in various capacities at Memorial University of Newfoundland, the University of New Brunswick and St. Mary's University. From 1996 to 1998, Neal worked as a contract biologist for the College of the North Atlantic in Labrador City and Happy Valley – Goose Bay where he also offered his services as a university tutor in various disciplines, including chemistry and biology. Neal was always there to help out whenever or wherever he could and would always without hesitation say "Yes, just provide me the materials." Students found him friendly and informative and they usually had few problems grasping concepts from him. He will be remembered for his willingness to help, his ability to teach a difficult content area and his friendly personality.

From November 1998, Neal was employed by the Provincial Government of Newfoundland and Labrador, Department of Natural Resources, occupying the position of Regional Ecologist for the Labrador Region. Neal's work concentrated on experimental design, data collection, and analysis of research projects relating to forest management plans in Labrador. Neal's research interests included effects of forest management and changing forest structures and specifically how these changes may affect the spatial and temporal distribution of threatened Woodland Caribou (*Rangifer tarandus caribou*) in central Labrador. Neal's most recent interests involved sustainable forest management in collaboration with the Government of Newfoundland and Labrador, Department of Natural Resources, and the Université du Québec à Montréal. Neal was about to embark on his post-doctorate research using innovative simulation models to ensure the sustainable management of Labrador's forests while his fiancée and co-worker Leanne would be completing her Master of Science in a supporting area of research. Neal was one of those rare ecologists who not only recognize the power of quantitative methods, but also actually understand how to appropriately apply these methods. Having just barely embarked upon his research career, Neal, as attested by his already growing list of publications, was destined for greatness in the world of research and statistics.

Since the summer of 2000, Neal had been an active participant in the North American Breeding Bird Survey (BBS) program and ran the Newfoundland and

FIGURE 1. Neal P. P. Simon holding his first seal darted off Mulligan Point, 2 May 2003. (Photo courtesy Sarah Townley).

Labrador, Happy Valley – Goose Bay survey route for Environment Canada. Neal was also a committed participant in the Christmas Bird Count (CBC).

Neal was a dedicated member of both the local Squash League and Goose Bay Judo Club. He exemplified the philosophy of Judo in all aspects of his life, striving to maximize his physical, intellectual and personal character by doing his best; and being his best, Neal truly reflected this teaching through his physical strength and fitness, his academic accomplishments and desire to learn. As a competitor, Neal was intense and spirited while always maintaining his youthful grin and sense of humour. Neal's enthusiasm for research in ecology and his jubilant attitude radiated from him, rapidly instilling in his colleagues a source of continual positive motivation. With an acute and intense sense of humour, Neal added a unique and welcome aspect to his interaction with both friends and fellow researchers. As an editor and reviewer of prospective manuscripts, his dedication and support were immeasurable and will be greatly missed.

In 1999, Neal was an original member of the Labrador Wolverine Working Group, and became one of the founding members of the Labrador Woodland Caribou Recovery Team in 2001. Neal was a member of The Society for Conservation Biology, the Wildlife Society, the Atlantic Region of the Canadian Climate Impacts and Adaptation Research Network, the Atlantic Society of Fish and Wildlife Biologists, Atlantic Co-operative Wildlife Ecology Research Network

(ACWERN), Newfoundland and Labrador Biodiversity working group, Forest Management Planning Team Member for Labrador Districts 19, 20, 21 and 22 and a member of the Institute for Environmental Monitoring and Research – Osprey Technical Committee. Neal was about to join the Groupe de recherche en écologie forestière interuniversitaire at l'Université du Québec à Montréal to complete his post-doctoral research developing habitat and timber harvesting-conservation trade-off models for Woodland Caribou.

Neal's interests were varied and included, but were not limited to, modelling species movements, predicting species distributions and understanding the effects of forest management on species occurrence and demography. He spent most summers in Labrador, along with his students and co-workers; in the field conducting songbird point count samples and vegetation plot counts.

We came to know Neal and build a strong friendship when he moved to Happy Valley – Goose Bay in 1998 and shortly thereafer began work as the Ecosystem Ecologist for Labrador. Neal was friendly, energetic and an avid waterfowl and big game hunter. We anxiously awaited mid spring each year when we would travel by snowmobile over the bay ice to Portage Island, Mulligan Point. Here we would participate in the eons old traditional Inuit hunting practice of waiting patiently at breathing holes for Ringed Seals (*Pusa hispida*). Evenings would be filled with laughter as we swapped humorous exaggerated stories of past good times. Such wonderful times were set against the backdrop of a blazing driftwood fire and the assurance of deep slumber later in our traditional Labrador canvas tents heated with the warmth of woodstoves. Neal often swapped related stories of how he had enjoyed the outdoors with his best hunting buddy, his father Dave, in Western Labrador. It was more important to Neal to enjoy the outdoors than to be successful on a hunt, though more often than not he was. As he so often mentioned to his hunting partner Colin Carroll, "If we don't get anything today, it doesn't matter. Just being here doing this is making my day."

His friends will best remember Neal as a shining, though comedic intellectual, with a love of life and a passion for the outdoors. Through discussions with some of Neal's colleagues and friends in the preparation of this tribute, we have found that Neal existed in several parallel universes, having the same mannerisms, characteristics and sharp wit despite the varied personalities and context of his friends. He will be remembered for his comic additions to his work and conversation slipping easily between extreme seriousness and laughter.

Acknowledgments

We thank Neal's parents (Dave and Doreen), his sister Nicole, fiancée Leanne, and others for personal information. Colin Carroll, Neal's schoolmate and colleague provided information on Neal's early schooling in Labrador City. We thank Tony Diamond for providing a compilation of Neal's academic achievements. Matt Betts and Joe Nocera provided insight on Neal's life that could only be shared between close colleagues and best friends. Bob Simms shared personal interactions with Neal through their judo club and Bernice Tracy provided details of Neal's association with the College of the North Atlantic. Finally, we would like to thank all of Neal's friends, family, colleagues and acquaintances that contributed to the Neal Simon Memorial Trust to fund an academic scholarship in Neal's honour and memory. Neal appreciated the outdoors and enjoyed hunting and fishing and spending time in the Labrador wilds with Leanne and his dog, Boss. He will be greatly missed by his family, his many friends and his academic colleagues.

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Compiled by TONY E. CHUBBS

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Book Reviews

ZOOLOGY

Amphibians and Reptiles of British Columbia

By Brent M. Matsuda, David M. Green, and Patrick T. Gregory. 2006. Handbook, Royal British Columbia Museum, Victoria, British Columbia. 266 pages. $17.33.

The British Columbia Provincial Museum (now the Royal British Columbia Museum) was second only to the Royal Ontario Museum to issue guidebooks to their provincial amphibian and reptile faunas for the public (by E. B. S. Logier in 1937 and 1939 for Ontario, and Clifford Carl in 1943 and 1944 for British Columbia). The Carl guides (Handbooks 2 and 3) subsequently went through reprintings with some revisionary material added in 1951 and 1968. In 1984 completely rewritten guides were published on reptiles (Handbook 44 by Gregory) and amphibians (Handbook 45 by Green), both coauthored with R. Wayne Campbell.

Now a new handbook (unnumbered) is a combined revised and partially rewritten text from the earlier Green and Gregory texts with updated distribution maps and the addition of a new coauthor. The previous authors are long-established, still active research herpetologists with extensive publications, Green primarily on frogs (in the broad sense including, as well as typical "frogs", toads, treefrogs, spadefoots, tailed frogs) and Gregory primarily on snakes but also including lizards, turtles and some amphibians. Dr. Gregory has spent his entire post-graduate career at the University of Victoria; Dr. Green was born British Columbian but his post-graduate career has been at the Redpath Museum at McGill in Quebec. Both have extensive field experience in British Columbia. The new addition, Matsuda, is characterised in the tongue-in-cheek authors' profiles (page 258) as an "overachieving ectotherm" (although this is surely not a unique characterization within this triumvirate) with a UBC M.Sc. who is now settled in British Columbia as an environmental consultant.

This handbook, like its predecessors, follows a standard guide layout. Preface, introduction (covering a wide range of aspects of amphibians and reptiles in general), checklist and conservation status, individual species accounts (for 39 species of which 4 are definitely and 2 possibly introduced) and a further section which includes additional introduced species which apparently have not persisted or whose occurrence is only speculative, an appendix which gives contact information for regional authorities, glossary of terms, bibliography (divided into additional reading and references), acknowledgements (about authors with illustrator credits) and an index. The black-and-white text drawings are mostly repeats from the earlier guides except for newly included wall lizard and all of the amphibians. A few of the latter are superior to those of the earlier amphibian guide but many are not. The new salamander drawings are particularly disappointing with the number of costal grooves shown rarely agreeing with the counts given in the text. However, all are sufficient for identification. New are 60 small colour photographs inserted between pages 186 and 187.

Additions since the last guide new to British Columbia and Canada are the secretive salamander *Plethodon idahoensis* and the introduced European wall lizard *Podacris muralis*. Also new is the conclusion from molecular evidence by T. R. Jackson in 1998 that the *Aneides* salamander on Vancouver Island is an import with bark from California, *A. vagrans*, and not the geographically closer *A. ferreus* to which it had long been assigned. Other nomenclature updates from recent revisionary studies are *Dicamptodon tenebrosus, Ascaphus montanus, Spea intermontanus, Actinemys marmorata, Pseudacris maculata, Rana luteiventris, Pituophis catenifer,* and *Crotalus oreganus*. One accepted elsewhere that was not made is *Pseudacris* for *Hyla regilla,* and the more controversial generic changes *Lithobates* for *Rana sylvatica* and *Rana pipiens* (but not for *R. aurora, R. pretiosa,* and *R. luteiventris*) and *Anaxyrus* for *Bufo boreas*, even though one of the authors (David Green) is a coauthor on the paper detailing the latter changes (American Museum of Natural History Bulletin 297).

Many incidental facts liven the text (such as the observation that frogs always close their eyes when they leap (page 14)), that frogs can "hear" ground-borne vibrations by transmissions through their front legs (pages 21-22) and that females of many turtles species can store sperm from a single male for up to four years (page 32).

The marine *Cadborosaurus* and the Okanagan Lake "Ogopogo" are only mentioned under folklore (page 49) with the (arguable by some) statement "Sporadic sightings of these beasts continue, but evidence of their existence is lacking."

Few slips were missed in proofing such as the failure to italicise *Hyla versicolor* and *H. chrysoscelis* on page 29, and the only British Columbia specimens of the horned lizard *Phrynosoma* given as "two near Osoyos in 1898" on page 182 but as "two records from Osoyos area in 1910" on the facing page 183 (the first is correct).

This guide brings British Columbia herpetology effectively into the 21st century as to be expected from the distinguished authors. It is a must for any west coast naturalist's bookshelf and/or field jacket with an outsized pocket.

FRANCIS R. COOK

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Blue Grouse: Their Biology and Natural History

By Fred C. Zwickel, and James F. Bendell. 2004. National Research Council of Canada, Ottawa, Ontario. 284 pages. $69.95 Paper.

This monograph is the culmination of two lifetimes devoted to studying Blue Grouse population biology and behaviour, both in the field and in aviaries, predominantly in coastal British Columbia. One of the advantages of a lengthy monograph is that the authors were able to synthesize much unpublished data and "gray" literature in addition to published references, making it the most comprehensive reference on this species group that is currently available. As such, it is not a book for the general reader of natural history (the colour and black-and-white photographs scattered throughout are quite small), but a scientific reference full of tables and graphs and lots of detail (there are 12 pages each of references and results of statistical tests).

Unfortunately, only two years after Zwickel and Bendell's monograph was published, the American Ornithologists' Union (Banks et al. 2006) re-split Blue Grouse into two taxa, *Dendragapus obscurus* in the Pacific Coast Range and the Sierra Nevada, and *D. fuliginosus* in the Rocky Mountains. These two taxa had originally been considered two species (Brooks 1929), but were conspecific for most of the 20th century. The re-split resulted from the recent DNA-based work of Barrowclough et al. (2004), who also found that the New Mexico populations of Dusky Grouse were perplexingly different, but not enough to consider them separate species. Populations in the northern parts of the range (i.e., north of the Chilcotin in central B.C., through to Alaska) were not included in the Barrowclough et al. study, but the separation into coastal and inland species is assumed to hold true. Unfortunately, the AOU split makes the monograph more difficult to use, but in their favour, Zwickel and Bendell use the scientific names, often with full trinomial reference to the eight accepted races at the time of publication, throughout, as well as referring to "coastal" and "interior" subspecies analogous to the new split. I recommend that the serious reader really study the chapter on taxonomy and distribution with Barrowclough's paper (available on the internet) in hand.

As a serious naturalist, I found the chapters on historical review, physical environment, integument (plumage especially), behaviour, habitat use and movement, population parameters, predators and disease the most interesting. The seven chapters on form and function – integument, morphology, reproduction, growth and development, food and nutrition, energetics and genetics – will be of interest mostly to serious students of Blue Grouse.

Although Zwickel and Bendell refer to studies from other parts of Blue Grouse range, they admit that the strong focus on the coastal species (*D. fuliginosus*) is unfortunate because there are a number of characteristics, such as vocalizations, that are clearly different between the two species. The authors hint at a future publication that will explore the population ecology of Blue Grouse, and it is to be hoped that they are able to overcome this geographical disparity.

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Birds of Peru

By Thomas S. Schulenberg, Douglas F. Stotz, Daniel F. Lane, John P. O'Neill, and Theodore A. Parker III. 2007 Princeton University Press. 656 pages. U.S. $49.50 Cloth.

In 2001 I was delighted to find *Birds of Peru*, by J. Clements and N. Shany. It was a good modern field guide and proved its worth in Peru. However, there were a few times when I needed to borrow a more comprehensive text to be certain of my identification. Now we have a new guide by Schulenberg et al. and the obvious question is whether it is an improvement.

The first difference is that the new guide has range maps. This means I do not have to struggle with phrases such as "on the east bank of the Rio Utacamba at the south end of Cordillera de Colon." [Marvelous Spatuletail] Now I can look at the map and have an immediate understanding. The range maps are conveniently set

next to the text in what is normally the margin, making great use of space. This alone is a great improvement.

Peru has about 1800 species or one fifth of the world's birds. Most sources cite this vague number. The few that are more precise give numbers that vary by up to 100 species. It is not surprising that a state of flux exists in such a vast and complex area. This book covers 1792 species which is probably as good as you do under such fluctuating circumstances. Trying to reconcile the list of species covered by both books or given in other sources is very difficult. It is a bit like trying to compile a list of "honest" politicians. The new book drops some questionable records like Plumbeous Ibis [one old, suspect, badly labeled specimen] but adds Bogota Rail [based on a current valid sighting.] Some birds are treated by Shulenburg as sub-species; Andean Ibis is listed as a sub-species of Black-faced Ibis whereas other sources give it full species status. There are complications due to name changes. For example, there are four toucans listed in both books. However, the names do not correlate well. This includes the scientific binomials, normally a very stable source of information. The old book has Toco Toucan *Ramphastos toco*, Black-mandibled Toucan *Ramphastos ambigus* Yellow-ridged Toucan *Ramphastos culminates*, and Cuvier's Toucan *Ramphastos cuvieri.* The new book has Toco Toucan *Ramphastos toco*, Black-mandibled Toucan *Ramphastos ambigus* plus White-throated Toucan *Ramphastos tucanus*, and Channel-billed Toucan *Ramphastos vitellinus*. The last two are new names for Cuvier's and Yellow-ridged Toucans. [Speciation in the whole toucan complex is confused.] I also noted that Andean Flamingo and James's [Puna] Flamingo have been updated to *Phoenicoparrus andinus* and *Phoenicoparrus jamesi,* respectively, but the Guanay and Red-legged Cormorants have not been changed to *Leucocarbo bougainvillii* and *Leucocarbo gaimardi*. So those with a penchant for lists may need to do some research. That being said, this book is more than adequate as a field guide for the resident and visiting birder alike.

The color plates are opposite the descriptions and distribution maps. There are 13 illustrators, so there is some difference in style. The most disparate are Laurence McQueen and John O'Neill. O'Neill's work has the precise, almost photographic rendering we see in most modern field guides. McQueen's paintings are more flowing and look like paintings. My junior school art teacher would have said they were more "painterly." Daniel Lane's work is somewhat in between these two styles. Which style you like is a matter of taste. I have looked at many of the illustrations for accuracy and can find no problems. In fact, I particularly like the toucanets by O'Neill and the jaegers by McQueen. There are 4000 color illustrations at about six to a plate, meaning the illustrations are quite large [again the publisher has used the margins].

In addition to the species accounts there are well-written sections on Habitats, Molts-and-Plumages, and Conservation. In particular the terminology used for habitat in the species accounts is clearly documented. The text in the species accounts covers the key identification features, status, distribution, and song.

This book will please birders and biologists living in or visiting Peru. It is also useful beyond the borders of Peru into adjacent areas of South America. It is a little on the heavy side for dragging through a hot jungle, but what else can you expect with such an enormous bird list.

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The Freshwater Fishes of British Columbia

By J. D. McPhail, illustrated by D. L. McPhail, foreword by Joseph S. Nelson. 2007. University of Alberta Press, Edmonton. lxxiv + 620 pages. $90.00.

This book is the latest treatment covering the freshwater fishes of British Columbia. Earlier books appeared in 1948 (132 pages) and 1967 (192 pages). They were published by the British Columbia Provincial Museum (now Royal British Columbia Museum) while the latest book is published, strangely, in Alberta. The present volume is 694 pages long with a larger format and is indicative of both the growth in knowledge and the need for a comprehensive work on this provincial fauna.

The book is composed of introductory sections covering purpose, use of keys, names of fishes, layout of the book, origins of the fauna, present distributions, and conservation. The sections on glacial events and current distributions are a very useful synthesis as is the discussion on what a species is and why the various forms of sticklebacks and others have not been named taxonomically.

The bulk of the text is the descriptions of species. Family accounts give general information on the included species and the identification keys are found there. The species accounts are preceded by a pictorial key to families that works for the more distinctive body shapes but would have benefited from some annotations for those fish that are more similar in shape to enable the naïve reader to correctly identify the family. It is always a debate as to whether keys should be with the family or should form a separate section. The former works when reading through the book but the latter is much easier for the actual identification process in a laboratory or the field. The keys are well illustrated al-

though both illustrations and text are too small. Particularly useful are keys to fry, parr, and adult salmons and trouts as these life history stages differ in appearance.

Each species account has a scientific name (but no date with the author), English common name, a black-and-white illustration, sections on distinguishing features, taxonomy, sexual dimorphism, hybridization, distribution with a spot map, life history, reproduction, age, growth and maturity, food habits, habitat and conservation comments.

A total of 81 species are covered, including 10 exotics. The main families of the 17 known from British Columbia are salmons, trouts and whitefishes with 23 species, minnows (20), and sculpins (8). Minor errors are inevitable in any work; e.g., Lindsey is misspelled in the dedication, Qadri as Quadri in the References, but some can be confusing; e.g., on page 498 *Pomoxis nigromaculatus* is said to have 5 anal spines in the sunfish identification key but most fish have 6-7 spines; the stickleback key separates two species by non-overlapping dorsal fin spine counts (which do, however, overlap occasionally) where in one species (*Pungitius*) the spines are staggered left to right, an easily seen and unique character (mentioned in Distinguishing Characters).

The book ends with an extensive Bibliography, an Appendix I (a checklist of the fishes, with no other appendices), a Glossary and an index to scientific and common names. The Glossary explains a variety of terms, even that the plural of dentary is dentaries which is fairly standard English, but gives axillae without explaining it is the plural of axilla (a knowledge of Latin is ever more dead). One obscure word is snye, defined as a dead-end side channel. This is listed in dictionaries as an Ontario word and can also mean a channel joining two rivers.

Cost is increasingly a factor in production of books and this may explain the absence of any colour plates. In my mind this argues for including a CD/DVD with the book to carry photographs of habitats and coloured depictions of fishes. The text can also be put on the disk, making the book searchable. I still prefer a book in the hand to a computer screen but suspect this does not apply to a younger generation. Even the CD in a pocket at the back of the book is a transitional stage and "books" should now appear on the internet, thereby saving trees, allowing a plethora of colour plates and other illustrations, enabling the author to receive and incorporate feedback and new data, and facilitating correction of errors of fact and of omission. A "book" on a website can be built up incrementally although some will inevitably fail to reach a completed form. Each stage allows for criticism and correction, from the initial checklist of species, the identification keys, distribution maps (allowing zoom-in for finer details than part of a book page allows), and finally text descriptions.

For those worried about vanishing websites, EM pulses and cyber trashing, a printout of say 20 copies of the digital "book" can be deposited in various libraries. This trend can be seen in some scientific works such as the "Annotated Checklists of Fishes" produced by the California Academy of Sciences which are on-line at that institution but have copies deposited in a minimum of six natural history institutions worldwide, admittedly as CDs.

This is the definitive book on this fish fauna and an essential tome for any student of the aquatic environment in British Columbia. Future versions will require multiple authors to match and improve on the experience and knowledge exhibited here by Don McPhail.

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Owls of the World

By J. Duncan. 2003. Key Porter Books, Toronto, Ontario. 319 pages. Hardcover, $60.

This beautiful book actually fulfills the two roles that many natural history books aspire to but usually fall short of … being both a detailed scientific reference and easy to read. The first two-thirds of the book cover the biology and life history of owls, stories by people who have uncovered these amazing details and the methods they used, the substantial role that owls have in mythology around the world, and threats to their survival (but also the passion and hope that people hold out for owls). The U.S. edition, published by Firefly Books, carries the apt subtitle "their lives, behaviour and survival".

The last third of the book is a detailed look at 205 species of owls: physical description, habitat, natural history, general distribution and their global conservation status. Even a quick look highlights how difficult it is to study some of these species, as many do not have photographs.

Duncan brings not only his own wealth of knowledge and field experience (particularly with Great Gray Owls) to this task, but also those of a "whoo's whoo" in the world of owls, such as Robert W. Nero, Irina Menyushina, C. Stuart Houston, and Aki Higuchi. Duncan's use of anecdotes helps to de-mystify science and raises the readability level, such as when he relates being dared to taste a freshly regurgitated owl pellet in front of a crowd. He said it tasted "sweet," but his incredulous darer (R. W. Nero) bit into it and quickly spat it out, declaring that it tasted "bitter." They were both right … the pellet is coated with a pH-neutral film of mucous that protects the owl's throat and mouth from the low-pH acid-soaked mass of fur and bones, which Nero had bitten into!

As with many species, owl populations are often in trouble around the world for the usual reasons: habitat destruction, direct (vehicles, shooting, trapping) and indirect (hitting barbed wire fences) mortality, and invasive alien species such as West Nile virus. But Duncan argues that an awareness and understanding of how people have perceived owls in the past may help support efforts to conserve them today.

The one small section of the book that many people will struggle to read describes the DNA sequencing and classification of owls. It would have been more understandable if Duncan had linked this highly technical description, especially the Maximum Likelihood Tree showing owl relationships, to some of the species accounts, where it is obvious from a glance at range maps for many of the Scops Owls in the Malaysian archipelago that these species probably had a common ancestor, and allopatric speciation occurred due to island isolation.

The photos in this book are luscious, with rich colour. Today, I randomly opened it and there was a full-page picture of Verraux's Eagle Owl – the best photo that I've seen of this owl that adequately shows its pinkish-purple eyelids. I recall driving along a sandy track in Chobe National Park in Botswana when one of my companions excitedly sputtered "purple eyelids, purple eyelids," as she pointed at the bird that had caught our attention in the guidebook!

Excuse me while I read up on the Tucuman Pygmy Owl before heading off to Argentina ....

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Ecology, Conservation, and Status of Reptiles in Canada

Edited by C. N. L. Seburn, and C. A. Bishop. 2007. Herpetological Conservation volume 2. Society for the Study of Amphibians and Reptiles, Salt Lake City, USA. x + 246 pages. illus., hardbound. Available from the Publications secretary of SSAR, ssar@herplit.com/U.S. $40 plus shipping.

This book is an edited compilation of peer-reviewed contributions on several aspects of conservation and more specifically, on the ecology of the reptiles that occur in Canada. It contains chapters by many (figurative) heavyweights of Canadian herpetology, who bring combined centuries of experience to the project. The book is a very good application of accumulated biological knowledge to the question of conservation. It is also a good example of how a professional community can collaborate in a common cause.

It begins with a short introduction, then a historical review of work done on reptiles in Canada. Next are four chapters summarizing the life history of lizards, snakes, freshwater turtles, and marine turtles. Contributions on the applications of genetics to conservation, health and disease in reptile populations, and traffic mortality follow. The future of Canadian reptiles and a strategy for conservation are discussed. The book ends with an illustrated checklist of species, with the official conservation status of each. There is also a comprehensive summary of literature, both historic and recent, with few omissions.

The book succeeds in its aim of providing a summary of the biology and conservation status of Canadian reptiles. The chapters are of a consistently high calibre – a testimony to the knowledge of the authors and the thoroughness of the editors. The book is useful on more than one level – as a summary of reptile ecology in Canada and as a conservation guide; the extensive literature is also a valuable resource.

Several themes are common to the contributions. Reptiles living in Canada face two problems – the climate and humans. Because climate affects life history, reptiles are concentrated in southern Canada, where it's warmer. Unfortunately for the reptiles, humans are concentrated in the same areas. Human activities that result in habitat modification are usually in direct conflict with the best interests of reptiles.

The book makes the point that although the Canadian climate may not be ideal for reptiles, they have adapted to life here. A reader soon realizes that many, if not all, declines in reptile numbers are due to human action. For example, road mortality is a common theme in several chapters. Human alterations to the landscape can have direct effects such as habitat destruction, and also secondary effects such as increases in reptile predators like cats and raccoons. Several authors make the point that declines in reptile, especially turtle, populations can occur slowly, drawing little public attention.

Although I was familiar with much of the information presented, there were some surprises, one being the high number of marine turtles off the Atlantic and Pacific coasts. This is but one example of how much is still not known about our reptile fauna.

Quibbles are few and minor. Colour variations and aberrant scutellation in turtles should not be included among diseases and parasites; the authors themselves admit that these "..are not detrimental..." (page 149).

What is the prognosis for reptile conservation? Although knowledge of the need for conservation is high among the public, and although the number of conservation programs is high, the future still looks bleak, because of the juxtaposition of human and reptile populations. The point is made repeatedly that while atlases and monitoring programs are good, they are ultimately ineffective without concrete action; "...ecological knowledge alone will not save species when the real problems facing them are social and political." (page 47).

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Rodent Societies: An Ecological & Evolutionary Perspective

Edited by J. O. Wolff and P. W. Sherman. 2007. The University of Chicago Press, Chicago, 610 pages. U.S. $49. Paper, $125 Cloth.

This opus on rodent behaviour brings together 61 researchers in a single edited volume. There are 42 chapters grouped into various topics including systematics, sexual behaviour, life histories, behavioural development, social behaviour, antipredator behaviour, comparative socioecology, conservation and disease. The main objectives are to present the latest research on the behaviour of rodents and to place it in the context of ecology and evolution. The resultant compilation of papers is firmly based on comparative biology, which goes beyond merely describing phenomena and explains it in terms of the larger ecosystem and within a phylogenetic framework. There is an emphasis on hypothesis testing and explicit experimentation that results in robust and scientifically-sound studies. This approach fostered by the editors gives more than just summaries of particular topics but highlights the ongoing nature of our understanding of behaviour in not only rodents but also as related to other organisms.

At over 2200 species, Rodentia is the most speciose order of mammals and accounts for approximately 40% of the diversity. In terms of breadth of coverage, almost half of the chapters summarize behavioural data across all major lineages of rodents or within a higher-level classification. In addition, many different groups or species of rodents are directly studied as case examples in this compendium, with taxa examined ranging from squirrels to beavers to rats to capybara.

After an introductory chapter on rodents as model systems, the evolutionary background is set with a paper discussing phylogenetics and biogeography. This is followed by several chapters on sexual behaviour dealing with mating and reproductive strategies. Life histories of rodents are covered by topics on dimorphism, sex ratios, stress, dispersal and philopatry, gene dynamics, and self-regulation. There is discussion of behavioural development such as neural regulation, ontogeny, learning, and kin recognition. Social behaviour is examined with papers on parental care, ecology of sociality, scent marking, non-parental infanticide, monogamy, and pacifism. There is a small section with three chapters on antipredator behaviour including alarm communication. Comparative socioecology has several papers on social organization and structure of a number of different species or higher-level groups. The book ends with a section on conservation and disease followed by a chapter summarizing conclusions and future directions on the research of rodent behaviour.

One weakness in an otherwise comprehensive anthology was the lack of molecular study on the genetic basis for much of the evolution of behaviour. In particular, DNA sequence data nowadays seems to be churning out by the genome. Was this an editorial oversight, or is there just nobody looking into this field of research for rodents? If so, this highlights an area that needs attention, especially since there are several candidate model-system species in rodents to choose from. Likewise, I found it odd that only four of the chapters have figures of phylogenies, considering that an evolutionary perspective is supposed to be one of the major underlying themes of the volume. Perhaps this is an indication that there is still an obvious gap that requires bridging between micro- and macroevolution.

Another observation is that over 80% of the authors are based at institutions in the Americas. Has this biased the presentation of the state of knowledge of rodent behaviour? A more subjective criticism is the combined literature cited section for the whole book. For edited volumes, I prefer references listed separately at the end of each chapter, especially when topics are as varied as this monograph. However, there are some advantages such as the elimination of repeated citations for general publications on rodents and a single compiled source useful for searching purposes. Nonetheless, these minor detractions by no means diminish from the scientific merits of the book.

This book is definitely aimed at the specialist researching the behaviour of rodents, but will also be of interest to biologists working on other organisms and studying similar social systems. At over 600 pages, the price is reasonable for purchase by a university library, or would be a valuable addition to any ecologist's bookshelf because it is packed with the latest information on ethology.

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Seashells: Jewels from the Ocean

By Budd Titlow. 2007. Voyageur Press, 729 Prospect Avenue, P.O. Box 1, Osceola, Wisconsin 54020. 112 pages. US $20. Cloth.

Sea shells have fascinated people since the dawn of time. Intrinsically beautiful, they have inspired artists and architects, been used to fashion tools, and have even served as money. They are also the prize of collectors the world over. All of these themes feature in Budd Titlow's handsome book *Seashells: Jewels from the Ocean*.

This relatively slender volume, copiously illustrated with photographs by the author or from stock footage, provides a good introduction to the world of mollusks and the shells which adorn so many of them. Successive chapters deal with the physiology of mollusks, their classification, their habitats, their cultural and econom-

ic importance to humans, and the threats that mollusks face. The latter include marine and land-based sources of pollution and over-exploitation of commercially valuable species.

There is also a primer on shell collecting, and also short notes on good collecting sites in North America. At its heart, this is a book aimed at shell collectors, be they casual beachcombers or fanatical conchologists. The former will learn much, the latter will no doubt admire the stunning photographs. There is a distinct American bias, both in the selection of photographs and in the shell collecting sites profiled; indeed at times the book reads as an ode to Sanibel Island, Florida, the Mecca of American shell collectors.

The book oscillates between straightforward explanations in layman's terms of the science underpinning malacology, and a rather folksy, and at times highly personal, appreciation of the cultural aspects of sea shells and shelling. While occasionally rather affected, on the whole it is highly readable. Many of the photographs selected sacrifice ecological verisimilitude for art; for example, there are several very beautiful assemblages that would be highly improbable in nature. And, belaying the book's American bias, it would be a fortunate day indeed where one found a Spider Conch (from the tropical Indo-Pacific) on a North American beach. For a field naturalist, the book is faintly disappointing in that it tends not to identify in specific terms most of the shells portrayed. Shelling, unlike birding, is one pastime where getting a grip on the Latin terminology and the taxonomy is essential; for this the reader would be well advised to turn to any one of the several excellent works cited in the short but useful reference section. By the same token, a few sketches illustrating such things as mollusk morphology would have been helpful.

There are a few errors in the text; for example the swans that winter at Chesapeake Bay are Tundra Swan, not Trumpeter Swan, but these errors do not detract from the overall value of the book. One somewhat disappointing aspect of the book, and one in counterpoint to the otherwise conservationist approach, is a section dealing with the collection of live specimens. While pale in comparison to other threats, collectors can pose a considerable threat to vulnerable species and it would have been preferable if the author had concentrated the reader's attention on the collection of non-living material. That said, the author does emphasize the need to respect local regulations. In conclusion, this book is not a scientific reference; however, it does provide a useful primer for anyone keen to explore the world of shelling, and a handsome addition to any collection of "coffee table" books.

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Turtles: An Extraordinary Natural History 245 Million Years in the Making

By Carl J. Franklin. 2007. Voyageur Press, 729 Prospect Avenue, PO Box 1, Osceola, Wisconsin 54020. 160 pages. U.S. $35.

Turtles provides a brief overview of the turtles of the world along with abundant colour photographs of many of the species. The book is divided into two parts. Part 1, the life and lifestyle of turtles, consists of three chapters. The first chapter covers the taxonomy and internal biology of turtles in roughly 10 pages. Chapter two, the ecology of turtles, covers topics such as thermoregulation, feeding, reproduction, and predators. The third chapter, covering the origin and fossil history of turtles, is only 3 pages long. Part 2, the diversity of modern chelonians, consists of two chapters. One chapter covers the families of Pleurodira, or side-necked turtles, and the other discusses the families of Cryptodira, or hidden-necked turtles. For each family account there is a map illustrating the global distribution of the family, then text discussing shared traits among members of the family and then information on many of the species within the family.

Roughly two-thirds of the books is allocated to Part 2, the family accounts. I found this an unsatisfactory balance. Part 1, which should provide a coherent picture of the various different turtle life history strategies, is just too short and superficial. Likewise, the family accounts remain superficial because they do not provide systematic species accounts. The information selected for individual species should highlight the unique qualities of that species, but all too often the species profiles rely on just some basic numbers (size, number of eggs laid), distribution (which countries it occurs in) and some general habitat info.

The text also has a number of glaring mistakes. In a text box on Linnaean taxonomy of turtles, the author states that turtles belong to the class Anapsida (page 14). In Linnaean terms, Anapsida is the subclass, while Reptilia (or Chelonia, for splitters) would be the class. The author claims that both McCord's Box Turtle (*Cuora mccordi*) and Zhou's Box Turtle *C. zhoui*) are believed to be extinct (pages 39-40), when really he should state they are likely extinct in the wild, as both species still occur in captivity. The author makes use of the most recent phylogenetic work on the genus *Clemmys*, by transfering the Wood Turtle (*Glyptemys insculpta*) to its new genus, but still leaves the Bog Turtle (*G. muhlenbergii*) in the genus *Clemmys*. Other careless errors include stating that there is more than one species within the genus *Actinemys* (page 98), and claiming that there are four species of Painted Turtle (*Chrysemys picta*; page 101), when really there are four subspecies. The Indian Flapshell Turtle (*Lissemys*

punctata) receives two different and somewhat contradictory species accounts, one brief account under its correct subfamily (Cyclanorbinae; page 134), and a longer account under an incorrect subfamily (Trionychinae; page 139). Despite these errors, there are some good things about this book. Part 1 does provide a very brief and readable introduction to the world of turtles. The photographs are generally quite good. Ultimately, however, this book could have been greatly improved by a thorough review from an expert on turtles.

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Whales and Seals Biology and Ecology

By Pierre-Henry Fontaine. 2007. Schiffer Publishing, 4880 Lower Valley Road, Atglen, Pennsylvania 19310 USA. 448 pages. U.S. $35. Paper.

During my career as a marine mammal research scientist I was reluctantly dragged in on several occasions to necropsy and dispose of large dead mammal carcasses found along the beaches of Canada's east or west coast. Almost always these mammoth mountains of mammalian flesh were in an advanced stage of putrefaction. Upon opening the body cavity one would confront what has been termed a "gaseous pudding" and it was challenging to properly identify even the most conspicuous organs. It is with this in mind that I say that I am impressed with the work in hand, which has yielded for the author a large amount of useful, detailed information, gathered with fortitude and persistence, from a source that many would have been wont to avoid.

The illustrations, particularly the excellent photographs of the organs and musculature, will serve as a valuable resource for field biologists learning their way around marine mammal carcasses. The author's expertise in marine mammals comes primarily from his extensive experience in performing necropsies of beach cast cetaceans and to a lesser extent pinnipeds. This book uses this as the point of departure relating the specific adaptations, the senses, nutrition, and locomotion, to the anatomical structures which he has studied and illustrated during his years of studies.

The remainder of the book attempts to give a general account of whales and seals, particularly from the North Atlantic, where the author has worked. The chapter on strandings is devoted to the question of why live cetaceans beach themselves. As the author points out, almost every imaginable reason has been offered from geomagnetic anomalies to suicide. The chapter leaves one hanging as do most articles on this subject. One very important recent work on this subject is the monograph *Marine Mammals Ashore* (J. R. Geraci and V. Loundsbury. 1993. Texas A&M Sea Grant Publication). This not mentioned by the author and would be a valuable source of additional information.

The chapter on mounting marine mammal skeletons will be found especially useful by museums and institutions wishing to do such displays. Little detailed information exists on this subject and the author has learned valuable lessons in avoiding errors in skeletal reconstruction from his numerous and careful field dissections.

The remaining chapters, while not based on the author's direct experience, are well researched and illustrated. The long association of people with whales and seals is presented in an interesting manner. Some specific examples of marine mammal hunting in the St. Lawrence are little known. The technique on Walrus hunting in the Magdalene Islands, which led to the early extinction of the southern-most Atlantic Walrus stock, is one such example.

The chapter dealing with the complicated subject of marine mammal paleontology gives a good introduction to a discipline which is both difficult to assimilate and where the information is not well organized in any single comprehensive source. This will serve as a good point of departure for students who want to learn more about the origins of marine mammals.

The last chapters, the fact sheets on Cetaceans and Pinnipeds, might be considered useful additions to this general work on marine mammals only because they include the species found in the North Atlantic, which is where most of the author's work has been done. One wonders why the author has included the Northern Elephant Seal (only found in the Pacific) and why the Pacific Walrus (*Odobenus divergens*) is mentioned and shown in one of the illustrations. The Arctic Ringed Seal, which is found as far south as the Labrador coast (Lake Melville) is omitted. A number of up-to-date field guides exist, which give a comprehensive account of the seals and whales in the North Atlantic and would serve their readers more effectively.

I recommend this book to the non-specialist who has an interest in whales in particular. It will also be a useful source of information for field biologists and naturalists who might deal with beach cast remains of marine mammals. It succeeds in what the author set out to accomplish by sharing his considerable knowledge of a subject, in which he has thoroughly immersed himself.

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ENVIRONMENT

China Ecosystems

Sun Honglie, *Editor-in-chief.* 2005. The Science Press of China. 1823 pages. 350 Yuan RMB Cloth.

The publication of such a magnum opus can be regarded as a landmark achievement accomplished by this group of Chinese ecologists. The book summed up the main results of the long-term research on the ecosystem structure and function at more than 80 ecological research stations, extensively distributed over China, of the Chinese Academy of Science. The research comprehensively covered the various fields such as ecosystem classification, ecosystem structure and dynamics, ecosystem energy flow, water and nutrient cycling in ecosystems, ecosystem management and sustainable use and so on.

China is a vast territory, richly endowed by nature and abounding in diverse types of ecosystems. Traditional Chinese integrative philosophy, an abundance of resources and the fast increasing economic power confer on China satisfactory conditions and capacity for ecosystem research. However, in China, the initiation of ecosystem research was rather late compared with many other countries. At the beginning stage in the 1950s, ecosystem research in China was very rare and scattered. This was nearly stopped during the ten-year period of the Cultural Revolution. China began to participate in the large international ecosystem research plans, such as IBP [International Biological Program], MAB [Man and Biosphere Program], IGBP [International Geosphere-Biosphere Program], GTOS [Global Terrestrial Observation System], EHA [Ecosystem Health Assessment], PAGE [Pilot Analysis of Global Ecosystem] [Pesticide Assessment Guidelines?] and MA [Millennium Ecosystem Assessment] from the late 1970s. Driven by these international programs, Chinese ecosystem research developed quickly, especially in recent years.

Long-term observational studies play an irreplaceable role in understanding and assessing the ecosystem structure, function and their health status. In this course, the ecological research stations made great contributions. The Chinese ecological stations, which are distributed throughout the typical ecological zones of China, have accumulated long-term continuous and dynamic data, not only on the changes of the same ecosystem types under different driving forces, and on the integrated features of different types of ecosystems at the regional scale, but also on the long-term ecological experiments and management practices conducted in these stations.

Most of Chinese ecosystems were generally healthy in the past; however, in recent years, at least some of them have undergone serious degradation, and some are even close to irreversible damage. Not long ago, China Environmental Protection Administration announced the first Report on the Ecological Protection in China, which admits that the trend of environmental deterioration in China has not been effectively curbed yet, and more than 60% of lands are becoming environmentally fragile. Obviously, to achieve sustainable development, China must continually improve its deteriorating environment, maintain and continuously upgrade the capacity of its ecosystem service, which needs a sound understanding of the effective management of various types of ecosystems in China.

The results of the long-term research on the Chinese ecosystems were achieved with a background of large temporal and spatial environmental changes. Therefore, the data accumulated by the Chinese ecological research stations (data used in this book), include the information not only on the progressive but also degrading succession of Chinese ecosystems, and the summary of some restoration practices. These results are particularly unique and valuable, and could be used as references for some other regions and countries.

The objective of the Millennium Ecosystem Assessment of the UN, which involves a large number of ecologists from different regions and countries, is to systematically and comprehensively reveal the trends of changes of various ecosystems, and accordingly propose effective countermeasures for the future. *China ecosystems* is certainly helpful for such an assessment and its publication is timely.

The book is composed of eight parts. The first part is General review, including Chapter one: the history, evolution and perspective of the ecosystem research; Chapter two: the natural conditions for the formation of the Chinese ecosystems; Chapter three: the evolution of the Chinese ecosystems; Chapter four: the impacts of human activity on the ecosystems; Chapter five: the principles and the systems of the Chinese ecosystem classification.

The second part is Forest ecosystems, including Chapter one: introduction; Chapter two: cold-temperate zone northern conifer forest ecosystem; Chapter three: middle-temperate zone conifer-broad-leaved forest ecosystem; Chapter four: warm-temperate zone deciduous forest ecosystem; Chapter five: subtropical zone evergreen and deciduous broad-leaved mixed forest ecosystem; Chapter six: subtropical zone evergreen broad-leaved mixed forest ecosystem; Chapter seven: subtropical zone western mountainous region evergreen hard-and-broad-leaved forest ecosystem; Chapter eight: subtropical zone alpine conifer forest and mountainous region conifer-broad-leaved mixed forest ecosystem; Chapter nine: tropical zone seasonal rain forest ecosystem; Chapter ten: tropical zone rain forest ecosystem; Chapter eleven: sustainable development of China forest ecosystems.

The third part is Grassland ecosystems, including Chapter one: the formation and classification of the grassland ecosystems; Chapter two: temperate zone grassland ecosystems; Chapter three: high and cold region grassland ecosystems; Chapter four: warm-temperate zone grassland ecosystems; Chapter five: tropical zone grassland ecosystems.

The fourth part is China's water ecosystems, including Chapter one: introduction; Chapter two: fresh water ecosystems; Chapter three: lake ecosystems; Chapter four: the succession and primary productivity of the lake ecosystems; Chapter five: ocean ecosystems.

The fifth part is Farmland ecosystems, including Chapter one: introduction; Chapter two: northeastern Song-nen Plain farmland ecosystems; Chapter three: lower field of Liao River Plain farmland ecosystems; Chapter four: north China Taihang Piedmont Plain farmland ecosystems; Chapter five: Huang-huai Plain farmland ecosystems; Chapter six: Tai Lake Plain farmland ecosystems; Chapter seven: South China hilly region farmland ecosystems; Chapter eight: Dongting Lake Plain farmland ecosystems; Chapter nine: Central Sichuan hilly region farmland ecosystems; Chapter ten: Loess Plateau farmland ecosystems; Chapter eleven: oasis farmland ecosystems in desert regions.

The sixth part is nutrient cycling in terrestrial ecosystems, including Chapter one: a review on the research progress of biogeochemical cycling; Chapter two: cycling of carbon and main nutrient elements in farmland ecosystems; Chapter three: cycling of main nutrient elements in forest ecosystem; Chapter four: cycling of main nutrient elements in grassland ecosystems.

The seventh part is water cycling in terrestrial ecosystems, including Chapter one: introduction; Chapter two: water cycling in farmland ecosystems; Chapter three: water cycling in forest ecosystems; Chapter four: water cycling in grassland ecosystems.

The eighth part is the theories and methods for the ecosystem network research, including Chapter one: the purposes and tasks for the ecosystem network research; Chapter two: the establishment and development of the ecosystem network; Chapter three: the methods for the ecosystem network research; Chapter four: the scales for the ecosystem network research.

The book was well written with few errors. Abundant illustrations are helpful for readers to easily understand the research results. The book is suitable for the professionals who engage in ecology or environmental science, or other persons who are interested in these fields.

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New Zealand – A Natural History

By Tui De Roy and Mark Jones. 2006. Firefly Books Ltd., Richmond Hill, Ontario. 160 pages. $40. Hardcover.

The authors, experienced professional photographers Tui De Roy and Mark Jones, moved to New Zealand about 16 years prior to the publication of the book, and, during this time, they explored many of New Zealand's distinct and often rugged and remote natural regions. The result of these explorations and hard work is this beautifully illustrated coffee table book containing more than 450 magnificent photographs which offer a wonderful introduction to many of the unique species and habitats of New Zealand. In keeping with one of the main areas of expertise of the authors – nature photography, the book is largely made up of beautiful pictures. Early in the book, there is a helpful map, which includes many of the locations and national parks referred to later on. The book also contains a reasonably detailed and useful index. As a biologist, I appreciated the inclusion – in an appendix just before the index – of a list of scientific and common names for many of the species named in the previous pages.

The text sections are fairly brief overall. I counted 39 pages covered mainly by text (not including the acknowledgments and index), out of the total 160 pages of the book. Thus, if one is planning a visit to New Zealand, reading the book prior to the departure may be easier than putting such a weighty, hardcover tome in the luggage.

Although brief, the text is not without merit. The authors have done their best to include information on a wide variety of animals and plants, as well as a few details about New Zealand's geological past and present. There are some interesting, although usually very short, stories about several species, including fist-sized giant carnivorous land snails – some of them endemic (restricted) to a single hill – that hunt large earthworms at night (some of the local earthworms can reach 1 meter in length) or the inquisitive kea, the very active mountain parrots of New Zealand, which are apparently capable of sometimes killing sheep and dismantling cars. There is a strong conservation theme throughout the book, and the main purpose of the text is clearly to highlight the plight of the many endangered species unique to New Zealand, and to discuss some of the conservation programs undertaken to save these rare species. This is a worthy goal, of course, and the authors' commitment to conservation is evident throughout.

However, as a scientist, I would have liked to see a more balanced and in-depth discussion of certain envi-

ronmental and conservation issues. The authors seem to take an uncritical approach towards some controversial control programs undertaken by the local Department of Conservation against species introduced to New Zealand by people, over the centuries. It is somewhat unsettling, for example, to read about the "Herculean aerial poisoning operation" – "the largest rodent control program ever undertaken anywhere in the world", on the same page where the authors refer to the "humane integrity" associated with the conservation initiatives such massive poisoning operations are a part of. It should perhaps have been mentioned, for example, that such massive poisoning operations can occasionally backfire, and affect rare native species as well. For instance, poisons used to eradicate mice also killed the North Island saddleback, a rare New Zealand native forest bird (Davidson and Armstrong 2002). Also, the magnitude of the effects of introduced herbivores on New Zealand's native plants can sometimes be difficult to determine (Veblen and Stewart 1982). In addition, it is worth noting that some species, such as the swallows and silvereyes mentioned by De Roy and Jones, expanded their ranges naturally into New Zealand in recent times. When it comes to the many interactions among introduced species and their new environments, the story is often considerably more complex than this book suggests. Thus, the repeated demonization of introduced species found in the text is often overly simplistic.

The authors often mention the negative impact of introduced wild mammals such as rats or Australian brush-tailed possums in New Zealand, but, curiously, seem to largely ignore the huge impact of New Zealand's domestic animals, particularly the country's enormous sheep population. According to Ponting (1993), there are more than 70 million sheep and 8 million cattle in New Zealand, and many of the habitats of this country have been changed drastically and irreversibly as a result. Also largely ignored in the book is a discussion of the early, pre-European, human-caused species extinctions. New Zealand's fauna used to be dominated by very large (the largest ones reached 3 meters in height) flightless birds called moa. These birds became extinct mainly due to overhunting by the Maori – the country's first human colonizers (Ellis 2004). The disappearance of the moas had important effects on some of the native plant species these giant birds were browsing on and had coevolved with. Thus, although conservation is, of course, a very important goal, it is also essential to recognize that nature is dynamic, and that the initial, pre-human colonization web of life found in New Zealand long ago can no longer be re-created due to the many irreversible changes that have taken place since then. A much more thorough and detailed discussion of New Zealand's prehistoric life and ecology can be found in the book by Worthy and Holdaway (2002).

Despite the shortcomings, the current work by De Roy and Jones represents a nice introduction to the unique natural world of this fascinating and remote country.

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MISCELLANEOUS

Beneath My Feet: The Memoirs of George Mercer Dawson

By Phil Jenkins. McClelland & Stewart, Toronto. 2007 Hardcover. 350 pages. 18 photographs, 6 sketches. $34.99.

Phil Jenkins set out to write the biography of George M. Dawson, the son of Sir John William Dawson, the first principal and then first president of McGill University. Jenkins has instead taken nearly 5000 of George Dawson's letters, most of them previously unpublished, from the McGill University archives, and has wisely allowed Dawson to write his own "autobiography." Jenkins has created an introduction in Dawson's style, has abridged an article published by Dawson in *Harper's Magazine*, and has written over 5% of the text (we don't know which segments) to fill in gaps not available in Dawson's own words. The result is a personal, frank, well-written, entertaining life of George M. Dawson, CMG, LLD.

A designer, "Mr. Richardson" (unaccountably, Jenkins does not provide his first name) has produced a charming book cover that fits perfectly with what would have been expected in the 1890s.

George M. Dawson was crippled in late childhood by spinal tuberculosis which left him a hunchback and a good foot shorter than he should have been. Nevertheless as an adult he struggled manfully through arduous hiking, canoeing and horseback riding that would have deterred many men of normal stature. He obtained superb training at the Royal School of Mines in London, England, where he was taught by Professor

Thomas Henry Huxley, a leading proponent of Darwin's theory of evolution. Young George was favourably inclined to Huxley's views and had spirited discussions on the subject with his father.

George M. Dawson was a geologist, author, teacher, civil servant, anthropologist, palaeontologist, surveyor, mapper, photographer, artist and poet. A number of his photographs, sketches, and poems are interspersed throughout this book. Although he was named geologist and naturalist to the North American Boundary Commission in 1873-74, his skills in natural history were weak (Jenkins fails to share this fact). In northern Montana, just south of the 49th parallel, he observed the last great herds of Bison and came across skeletons resulting from the slaughter of 21 plains Indians. Dawson named a number of geographic features in the Queen Charlotte Islands and the interior of British Columbia that are still in use today. He suffered the pain of unrequited love and remained a bachelor until his premature death from an acute chest infection at age 51.

I agree with Jenkins (page 2), that Dawson was "a writer ... of endearing wit, evocative description, and illuminating fact." He described an Orkneyman in the employ of the Hudson's Bay Company as "an amiable Hudson Bay Fossil." He used the term "liquid excisable articles" to describe spirituous liquors.

This book has not achieved its full potential. I spotted the following misspellings and factual errors, presumably made by Dawson and not by Jenkins: alumni (when alumnus was indicated), latitude (when longitude was meant), astrological (astronomical), peninsular (peninsula), tit bits (tid bits), 100th meridian (110th meridian), prairie chickens (Sharp-tailed Grouse), Dr Helckin (Dr Helmcken), F.R.C. (F.R.S.), silver load (silver lode), and Bearing Sea (Bering Sea). There is little doubt that a University press would have encouraged Jenkins to insert the correct spellings in square brackets, as well as to include an index, explanatory footnotes (e.g., to add the initials and explain the importance of Dr. W. F. Tolmie, surgeon to the Hudson's Bay Company), and a bibliography. The latter would have included *Life and Letters of George Mercer Dawson, 1849-1901*, by Lois Winslow-Spragge, Dawson's niece, and would have listed the available photocopies of Dawson's detailed field notebooks which Jenkins seems to have ignored. Similarly, we are not told that Sapper Duckworth was Dawson's collector and taxidermist in 1873-74, that white cranes were Whooping Cranes, that the blue jay was probably a Steller's Jay, that the hummingbird nest was likely that of a Rufous Hummingbird, and that the name of the destructive but now extinct Rocky Mountain Locust has since changed from *Caloptenus spretus* to *Melanoplus spretus*.

A longer introductory essay or a postscript could have allowed a more complete assessment of Dawson's great achievements which Dawson modestly did not mention. We learn, for example, that Dawson received an honorary doctorate from the University of Toronto, but those from Princeton, Queen's and McGill, and other high honors, are not mentioned.

In spite of the shortcomings mentioned, Dawson's skills make this book a treasure, a lasting contribution to Canadian history. I recommend it highly to the general public. It deserves a place in every university and high school library.

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The Wolf Totem

By Jiang Rong. 2004. Changjiang Literary Art Press. Pages: 478; $18. Yuan RMB.

[*Editors note:* The Penguin Group, under the British Pearson Education Company, bought the copyright and will publish an English version in 2007. This researched-based novel has topped China's bestseller list for 16 straight months, selling about 1 million copies.]

The Chinese press has not published a significant book in many years. However, in April of 2004, the Changjiang Literary Art Press of China published the novel-style book *The Wolf Totem*, which was written by an author bearing the pseudonym Jiang Rong. The response from the media and the public was rapid and it became a best seller.

The book is composed of various relatively independent stories. The narration of each story is full of craftsmanship, firing one's imagination and stirring one's emotion. The novel-style book is a marvellous, unprecedented way to present many stories of the enigmatic animal of the steppe, the wolf. The stories are not only charming in their sense of humanity, but also colourful and valuable in their understanding of the ecological role played by the Wolf. After reading the book, readers will be enlightened, moved and even shocked by the vivid ecological ethics conveyed in the book. The publication of the book can be regarded as an important event for both literature and ecologists.

From the viewpoint of ecology, a steppe may be regarded as a special type of ecosystem seemingly simple in structure and function, but essentially diverse, complicated and unpredictable. From the perspective of humanity, a boundless steppe may be mysterious, thought inspiring and soul stirring, sometimes touching and sometimes plaintive. In the cultural evolutionary history of the world, the acted steppe as an endless wellspring of artistic creation and a boundless field for sci-

entific exploration. The anecdotes and the legends, the music and the paintings related to the steppe are uncountable; the study cases concerning the steppe ecosystem are also voluminous.

Turning aside from the fascinating visions and thrilling scenes the author describes in each story, and turning aside from the totem of wolf at the level of politics and humanities the author elucidates in his narration, the book is of important ecological values. The descriptions of the behaviours of the Wolf populations in teamwork, reconnaissance, ambuscade, and surprise attack, and the unusual wisdom exhibited in making use of weather and topography, as well as the discussions on the relationships among the populations of Wolf and human, sheep and grass can be regarded as very vivid and enlightening material. However, it is a pity that in an otherwise valuable book that the author does not give the basic scientific and quantitative relationships among the component populations of the ecosystem. This may be beyond the scope of this style of book.

All these mysterious stories took place in the steppes of northern China during a special period more than nearly 40 years ago when the author and his classmates as urban school graduates laboured in the countryside in response to the political call of Chairman Mao. At that time, the vast area of steppe of northern China had plenty of water and lush grass, creating a beautiful landscape. But afterward, due to overgrazing and farming, the steppe ecosystem degenerated rapidly.

China is the second largest country in the world in terms of the steppe area. However, due to the increase in large scale agriculture in the half century from 1949, 5% of the natural steppe area was turned into farmland [This constituted one fifth of the total farmland of China]. This has resulted in more than a quarter of Chinese land being threatened by desertification. More than 90% of the steppe has been degenerated and such degeneration is expanding at the rate of 2 million km^2/yr. Since steppe restoration is becoming harder and harder in China, all the stories about the steppe in the past are becoming almost unrepeatable. This further implicates the extreme rarity and the important value of the material in this book.

Ecosystems with multiple-trophic levels are complicated and maintaining the stability is critical. In a typical steppe ecosystem with three trophic levels: carnivore, herbivore and grass, the carnivore usually plays a top-down effect on the community structure, and by this means grass tends to be protected to some extent. The theory of trophic cascade and HSS hypothesis is useful in explaining, "Why the terrestrial world tended to be green." McLaren and Peterson (1994) used tree ring data to show how a top-down effect of Wolf populations on Isle Royale reduced Moose abundance resulting in an increase in the growth increment of forage trees. *The Wolf Totem* shows that in the northern China about one century ago, harmonious relationships among the component populations of the ecosystem did exist, and the relative stability of the pasture was naturally maintained. This supports the rationality of the theories as mentioned above. However, considering the present situations of the rapidly degenerated steppe ecosystem in northern China, the above-mentioned theories encounter limitations, because they do not deal with how and why "the terrestrial world turned from green to yellow or black" due to over-use and human disturbance. If a disturbance dimension was added to the theories and each dimension were given a threshold, the theories would become more general, compatible and extendable.

The Mongolians, the native people in the northern China, fully understood the natural laws of mutual restriction and dynamic balance among the population of wolf, sheep and grass in the steppe ecosystem in their long history dealing with nature, and knew how to efficiently live within these laws. They never killed all of the Wolves, never bred the sheep excessively and never over-grazed the pasture. The accumulation of such ecological wisdom imitating nature, acclimating nature and making use of nature, moulded the Mongolian nationality. On the contrary, by disobeying the laws of nature, they have unavoidably learnt a painful lesson about the degeneration of the steppe.

When human or social-economic dimensions are added into a natural ecosystem, it would become a social-economic-natural-complex-ecosystem (SENCE). The present steppe ecosystem in northern China is such a SENCE. Keeping such a SENCE developing in a harmonious way is a new challenge to China with ever-increasing population. The classical Chinese philosophy, such as *The Doctrine of the Mean*, emphasizes human's active roles such as participation, promotion, coordination and cultivation rather than domination, so as to reach harmony between human and nature. Combining the classical Chinese philosophy with the modern ecological theories and using the actual experiences and lessons for references, steppe-like SENCE would be managed more effectively. *The Wolf Totem* with its stories of a rural youth living among Inner Mongolian nomads and wolves tells of this grassland environment and nomadic culture. Reading *The Wolf Totem* will bring the reader a better understanding of the ecology of the Chinese-Mongolian steppe.

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YOUNG NATURALISTS

Gracie. The Public Gardens Duck

By Judith Meyrick. Illustrations by Richard Rudnicki. 2007. Nimbus Publishing Limited. Halifax, Nova Scotia B3K 5MB Canada. 32 pages. $16.95. Cloth.

This is a delightful children's book, told from the perspective of Gracie the duck. The story is about the duck's quest for food crumbs in a public park near the CBC building in Halifax. Gracie spends most of her time, quite successfully, getting the attention of different people she sees in the park so that they will share their food with her.

However, one day, people are not giving food to her. "Mr. Black Suit", the person who usually feeds her, does not proffer up any of his muffin; nor does a pair of school girls, who actually apologize to Gracie. A young girl almost shares a piece of her peanut butter sandwich, until the girl's mother reminds her of the sign near the park entrance. What sign? What is going on? Gracie asks herself, puzzled about this change in her daily feeding regimen.

Finally, hungry Gracie reads some of the words on the sign and discovers that park policy has changed and feeding the ducks is no longer allowed. Gracie takes action, but even this doesn't work. The hungry duck is then forced to try the insects in the grass and then some plants in the pond, and finds that these are very satisfying. Pleased with herself, she now realizes that there is plenty of food in the park without relying on people for crumbs such as Mr. Black Suit – who comments to Gracie that she has adapted nicely.

The story is very compelling and suitable for ages 3 to 8 (at least) – my 12-year-old niece picked up the book and enjoyed it as much as her younger sisters did. The illustrations are dynamic and it is almost as if the people and ducks in this story are moving as you read it. Truly a delight – with a good lesson learned along the way.

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NEW TITLES

Prepared by Roy John

†Available for review * Assigned

ZOOLOGY

[Editor's note: The following publications are available from China Scientific Book Services, Jian Nei Da Jie Post Office, 100001-88, Beijing, China or e-mail order: order-csbs@94book.com.cn, Online order: http://www.hceis. The publication dates and costs vary and not all have English text.

Fauna Sinica Invertebrata Volume 1: Crustacea Freshwater Cladocera

Fauna Sinica Invertebrata Volume 2: Arthropoda Crustacea Freshwater Copepoda

Fauna Sinica Invertebrata Volume 3: Platyhelminthes: Trematoda: Digenea (1)

Fauna Sinica Invertebrata Volume 4: Cephalopode

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Fauna Sinica Invertebrata Volume 6: Holothuroidea

Fauna Sinica Invertebrata Volume 7: Gastropoda: Mesogastropoda: Cypraeacea

Fauna Sinica Invertebrata Volume 8: Arachnida: Araneae:Thomisidae and Philodromidae

Fauna Sinica Invertebrata Volume 9: Polychaeta: Phyllodocimorpha

Fauna Sinica Invertebrata Volume 10: Arachnida: Araneae: Araneida

Fauna Sinica Invertebrata Volume 11: Gastropoda: Opisthobranchia: Cephalaspidea

Fauna Sinica Invertebrata Volume 12: Bivalvia: Mytiloida

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Fauna Sinica Invertebrata Volume 16: Anthozoa: Actiniaria, Ceriantharia and Zoanthidea

Fauna Sinica Invertebrata Volume 17: Crustacea: Decapoda: Parathelphusidae and Pota midae

Fauna Sinica Invertebrata Volume 18: Protura

Fauna Sinica Invertebrata Volume 19: Gastropoda: Pulmonata: Stylommatophora: Clausiliidae)

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Fauna Sinica Invertebrata Volume 21: Crustacea: Mysidacea

Fauna Sinica Invertebrata Volume 22: Monogenea

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Fauna Sinica Invertebrata Volume 25: Nematoda: Rhabditida: Strongylata

Fauna Sinica *Invertebrata* Volume 26: Phylum Granuloreticulosa Class Foraminiferea Agglutinated

Fauna Sinica Invertebrata Volume 27: Hydrozoa and Scyphomedusae

Fauna Sinica Invertebrata Volume 28: Crustacea: Amphipoda:Hyperiidea

Fauna Sinica Invertebrata Volume 29: Gastropoda: Archaeogas-tropoda: Trochacea

Fauna Sinica Invertebrata Volume 30: Crustacea: Brachyura: Marine Primitive Crabs

Fauna Sinica Invertebrata Volume 31 : Bivalvia: Pteriina

Fauna Sinica Invertebrata Volume 32: Polycystinea: Nasellaria: Phaeodarea: Phaeodaria

Fauna Sinica Invertebrata Volume 33: Annelida Polychaeta II Nereidida

Fauna Sinica Invertebrata Volume 34: Mollusca Gastropoda Tonnace

Fauna Sinica Invertebrata Volume 35: Arachnida: Araneae: Tetragnathidae

Fauna Sinica Invertebrata Volume 36: Crustace Decapoda Atyidae

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Fauna Sinica Invertebrata Volume 38: Chaetognatha: Sagittoidea

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Fauna Sinica Invertebrata Volume 41: Crustacea Amphipoda Gammaridea (1)

Fauna Sinica Invertebrata Volume 44: Crustacea Decapoda Palaemonoidea

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The fauna of Hebei, China-Araneae

Economic Fauna of China: Terrestrial Mollusks

Economic Fauna of China: Freshwater Mollusks

Economic Fauna of China: Marine Mollusks

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News and Comment

Marine Turtle Newsletter (115)

January 2007. 32 pages: EDITORIALS: Guest Editorial (P C. H. Pritchard) — Beach Driving Management Cape Hatteras and Cape Lookout National Seashores, USA (L. R. Nester and N. B. Frazer) — ARTICLES: Interactions Between Marine Mammals and Turtles (D. Fertl and G. L. Fulling) — Identification of Bacterial Isolates from Unhatched Loggerhead Sea Turtle Eggs in Georgia, USA (K. S. Cravem. J. Awong-Taylor, L. Griffiths, C. Bass, and M. Muscarella — NOTES: Captive-raised Loggerhead Turtle Found Nesting Eight Years After Release (A. de Padua Almeida, C. Baptistotte, A. S'A dos Santos, and T. Z. Serafinai) — Tarballs and Early Life Stages of Sea Turtles in Paraiba, Brazil (R. G. Santos and E. F. Mariano) — Rapid Survey of Marine Turtles in Agalega, Western Indian Ocean (O. Griffiths and V. Tatayah) — Kemp's Ridley Shell Damage (W. N. Witzell) — Live Loggerhead Observed in Newfoundland, Canada in Late Autumn (W. Ledwell) — IUCN-MTSG QUARTERLY REPORT — MEETING REPORTS — OBITUARY: Boyd Nathaniel Lyon 1969-2006 (Peter C. H. Pritchard) — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

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COVER: Four Maritime Garter Snakes, *Thamnophis sirtalis pallidulus*, observed in courtship behavior on the branches c Rhododendron shrub at 325 Prince Albert Road, Dartmouth, Nova Scotia, on 5 September 2006. See note by Gilhen an Strum pages 210-211.

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The Canadian Field-Naturalist

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Diversity and Distribution of the Terrestrial Mammals of the Yukon Territory: A Review

Brian G. Slough[1] and Thomas S. Jung[2]

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Slough, Brian G., and Thomas S. Jung. 2007. Diversity and distribution of the terrestrial mammals of the Yukon Territory: A review. Canadian Field-Naturalist 121(2): 119-127.

The diversity and distribution of the terrestrial mammals of the Yukon has not been systematically reviewed since 1975, a time when the occurrences of many species were not well known. Since then, single species and community studies, biological collections and expert observations have increased our knowledge of the land mammals of the Yukon. Taxonomic studies have resulted in some additional species. We provide an update on the diversity and distribution of recent land mammals of the Yukon, including previously unreported range extensions, and include a revised checklist. Research in adjoining jurisdictions has contributed more hypothetical species for the Yukon. The mammalian fauna of the Yukon is in a relatively dynamic state, and human-induced changes, particularly climate warming, will undoubtedly influence mammalian diversity and distributions in the coming decades.

Key Words: biological diversity, Beringia, checklist, distribution, Mammalia, Yukon.

Philip Youngman (1975) provided the most comprehensive survey of the recent mammals of the Yukon. That information was based on a survey of observations and biological collections from the late 1800s to mid-1970s, and is now over 30 years old. A recent increase in interest in mammals, particularly non-harvested species, rare species, and species at risk, has resulted in new information and corrections to previously reported distributions. The evolution of the territorial wildlife management agency, the establishment of a conservation data centre, several university-based research projects (most notably near Kluane Lake; see Krebs et al. 2000), documentation of local and traditional knowledge, and a number of resident and visiting naturalists have all contributed much new information. Changes in taxonomy and nomenclature have also occurred since Youngman (1975), with the former particularly advanced with the use of phylogeographic analyses to differentiate taxa. DNA analyses have also helped detect the presence of cryptic species (e.g., *Myotis*, *Myodes*, and *Peromyscus* spp.) that are difficult to identify to the species level in the field. Herein, we provide an update of the terrestrial mammals of the Yukon Territory; an interesting zoogeographic area of Canada with both Beringian and post-glacial immigrant species from southern refugia.

Methods

We reviewed information from published and unpublished work, collections, and sightings made since Youngman (1975), primarily chronicling the period from the mid-1970s to the present. We identified and report on changes in species known to be present and update their distributions since Youngman (1975) and others (e.g., Banfield 1974; van Zyll de Jong 1983, 1985). Species without noteworthy changes are not discussed in our review; however, all documented species occurring in the Yukon are provided in a checklist (Table 1). Scientific names and English common names follow Wilson and Reeder (2005) except Caribou which replaces Reindeer. In addition, we have also extrapolated ranges of species found in neighboring jurisdictions to compile a list of hypothetical species. We did not consider the marine mammals of the Beaufort Sea.

Order Soricomorhpa (Insectivores)

Seven species of soricomorphs, representing one family (Soricidae), are recorded from the Yukon (van Zyll de Jong 1983; Table 1). Few surveys specifically for shrews have been undertaken in the Yukon and because they are most efficiently captured in pitfall traps (Prince 1941; MacLeod and Lethiecq 1963), they are likely undersampled using standard methods for small rodents (i.e., live-traps or snap-traps).

TABLE 1. Checklist of the terrestrial mammals of Yukon. Scientific and English common names follow Wilson and Reeder (2005).

Order / Family	Scientific Name	English Common Name
SORICOMORPHA		
Soricidae	*Sorex arcticus*	Arctic Shrew
	Sorex cinereus	Cinereus Shrew
	Sorex hoyi	American Pygmy Shrew
	Sorex monticolus	Dusky Shrew
	Sorex palustris	American Water Shrew
	Sorex tundrensis	Tundra Shrew
	Sorex ugyunak	Barren Ground Shrew
CHIROPTERA		
Vespertilionidae	*Eptesicus fuscus*	Big Brown Bat
	Myotis lucifugus	Little Brown Myotis
	Myotis septentrionalis	Northern Myotis
LAGOMORPHA		
Ochotonidae	*Ochotona collaris*	Collared Pika
Leporidae	*Lepus americanus*	Snowshoe Hare
RODENTIA		
Sciuridae	*Glaucomys sabrinus*	Northern Flying Squirrel
	Marmota caligata	Hoary Marmot
	Marmota monax	Woodchuck
	Spermophilus parryii	Arctic Ground Squirrel
	Tamias minimus	Least Chipmunk
	Tamiasciurus hudsonicus	Red Squirrel
Castoridae	*Castor canadensis*	American Beaver
Cricetidae	*Dicrostonyx groenlandicus*	Nearctic Collared Lemming
	Dicrostonyx nunatakensis	Ogilvie Mountains Collared Lemming
	Lemmus trimucronatus	Nearctic Brown Lemming
	Microtus longicaudus	Long-tailed Vole
	Microtus miurus	Singing Vole
	Microtus oeconomus	Root Vole
	Microtus pennsylvanicus	Meadow Vole
	Microtus xanthognathus	Taiga Vole
	Myodes gapperi	Southern Red-backed Vole
	Myodes rutilus	Northern Red-backed Vole
	Neotoma cinerea	Bushy-tailed Woodrat
	Ondatra zibethicus	Common Muskrat
	Peromyscus keeni	Northwestern Deermmouse
	Peromyscus maniculatus	North American Deermouse
	Phenacomys ungava	Eastern Heather Vole
	Synaptomys borealis	Northern Bog Lemming
Dipodidae	*Zapus hudsonius*	Meadow Jumping Mouse
	Zapus princeps	Western Jumping Mouse
Erethizontidae	*Erethizon dorsatum*	North American Porcupine
CARNIVORA		
Canidae	*Canis latrans*	Coyote
	Canis lupus	Wolf
	Vulpes lagopus	Arctic Fox
	Vulpes vulpes	Red Fox
Ursidae	*Ursus americanus*	American Black Bear
	Ursus arctos	Grizzly Bear
	Ursus maritimus	Polar Bear
Mustelidae	*Gulo gulo*	Wolverine
	Lontra canadensis	North American River Otter
	Martes americana	American Marten
	Martes pennanti	Fisher
	Mustela erminea	Ermine
	Mustela nivalis	Least Weasel
	Neovison vison	American Mink
Felidae	*Lynx canadensis*	Canadian Lynx
	Puma concolor	Cougar

TABLE 1. *(continued)*

Order / Family	Scientific Name	English Common Name
ARTIODACTYLA		
Cervidae	*Alces americanus*	Moose
	Cervus elaphus	Elk
	Odocoileus hemionus	Mule Deer
	Odocoileus virginianus	White-tailed Deer
	Rangifer tarandus	Caribou
Bovidae	*Bison bison*	American Bison
	Oreamnos americanus	Mountain Goat
	Ovibus moschatus	Muskox
	Ovis dalli	Dall's Sheep

Stewart et al. (2003) reported a specimen of Pygmy Shrew, *Sorex hoyi*, from the Ogilvie Mountains which would be a northern range extension; however the coordinates given for the specimen align with Dawson City (64°03'N, 139°25'W). Subsequently, a specimen was retained in 2005 from the Blackstone River in the Ogilvie Mountains (65°05'N, 138°11'W; Jung et al. 2007), representing a northern range extension of about 110 km.

The range of the American Water Shrew, *S. palustris*, has been extended northward since Youngman (1975) and van Zyll de Jong (1983) and it is now known to as far north as the Tombstone Range of the southern Ogilvie Mountains (Jarrell 1986; Cook et al. 1997). It has been observed near the tree line on Hamilton Creek, 30 km southeast of the Tombstone Campground (64°19'N, 137°38'W; J. Schou, personal communication).

The Tundra Shrew, *S. tundrensis*, is known from the northern Yukon south to Fortymile (64°26'N, 140°32'W Youngman 1975), where three additional specimens were obtained in 2003 (B. Slough and T. Jung, unpublished data). In the late 1970s five Tundra Shrews were trapped in alpine and subalpine habitats on the Haines Road in British Columbia within 20 km of the southwest Yukon, and about 500 km south of its previously known limits (Nagorsen and Jones 1981). It was thought to be limited to Beringia, a region unglaciated during the Wisconsin glaciation; however, the British Columbia locations are 500 km from the limits of Beringia and confound the expected distribution pattern (Nagorsen and Jones 1981). It may yet be found in the intervening area in the Yukon.

The Arctic Shrew, *S. arcticus*, remains known only from a single skull collected in 1965 (Youngman 1975), despite substantial subsequent survey effort for shrews (e.g., T. Jung and colleagues, unpublished data; J. Cook and colleagues, unpublished data). Further collections are required to assess its distribution in the Yukon.

Order Chiroptera (Bats)

Three species of bats, representing one family (Vespertilionidae), are reported from the Yukon (Table 1). Youngman (1975) reported only the Little Brown Myotis, *Myotis lucifugus*, from the Yukon, where it is widespread and common south of 64°N. Since Youngman (1975), the Northern Myotis, *M. septentrionalis*, has been confirmed (Jung et al. 2006a) and another species, either the Big Brown Bat (*Eptesicus fuscus*) or Silver-haired Bat (*Lasionycteris noctivagans*), has been recorded via acoustic sampling (B. Slough, unpublished data). Until recently, few mist-net or echolocation monitoring surveys for bats had been undertaken in the Yukon, and it is likely that the Order remains undersampled. Based on surveys in adjacent jurisdictions, there may be other species of bats present in the Yukon that are not yet documented.

The Northern Myotis, *M. septentrionalis*, was first found in the Yukon in 2004 when three individuals were captured at the La Biche River (60°08'N, 124°04'W; Jung et al. 2006a). Five additional specimens were captured in 2007 near Watson Lake (60°07'N, 128°49'W; Lausen et al. 2008). This species has also been captured at several locations in the Liard watershed of northern British Columbia (Wilkinson et al. 1995*; Bradbury et al. 1997*; Crampton et al. 1997*; Vonhof et al. 1997*; Vonhof and Wilkinson 1999*) and in the southern Northwest Territories as far west as Nahanni National Park (van Zyll de Jong 1985; Lausen 2006*).

Youngman (1975) had listed the Big Brown Bat, *E. fuscus*, as a hypothetical species for the Yukon based on a record from interior Alaska (Reeder 1965). In September 1999, B. Slough (unpublished data) made a recording of a bat echolocation call sequence with an AnaBat II bat detector (Titley Electronics, Ballina, New South Wales, Australia) at Morris Lake (60°25'N, 131°38'W) that was most likely *E. fuscus* (C. Corben, personal communication; Keinath 2004*). This is possibly the first record of the species from the Yukon, although it may be difficult to distinguish the echolocation calls of *E. fuscus* from those of Silver-haired Bats, as recorded with an AnaBat detector (Betts 1998). There is a single record from central Alaska (Reeder 1965) and unsubstantiated reports exist for southeast Alaska (MacDonald and Cook 1996). *E. fuscus* had been recorded on bat detectors in the Liard watershed in northern British Columbia (Wilkinson et al. 1995*;

Bradbury et al. 1997*; Crampton et al. 1997*) and southwestern Northwest Territories (Lausen 2006*).

Order Lagomorpha (Pikas and Hares)

As noted by Youngman (1975), two species of lagomorphs, representing two families (Ochotonidae and Leporidae) are recorded from the Yukon (Table 1).

The southeastern limit for the Collared Pika, *Ochotona collaris*, shown by Youngman (1975) was the Logan Mountains. It has since been sighted approximately 200 km east-southeast in the Kotaneelee (2004; 60°27'N, 124°12'W) and La Biche (1998; 60°14'N, 124°32'W) ranges (B. Bennett, personal communication).

Order Rodentia (Rodents)

There are 26 known species of rodents, representing five families (Sciuridae, 6 species; Castoridae, 1 species; Cricetidae, 16 species; Dipodidae, 2 species; Erithizontidae, 1 species), recorded from the Yukon (Table 1).

The Northern Flying Squirrel, *Glaucomys sabrinus*, occurs throughout the forests of the southern Yukon (Youngman 1975). It has been observed near the treeline on Hamilton Creek in the Ogilvie Mountains (64°20'N, 137°39'W; J. Schou, personal communication), confirming the northern range limit projected by Youngman (1975).

The Hoary Marmot, *Marmota caligata*, has been confirmed in the La Biche Range in the extreme southeast Yukon (60°14'N, 124°32'W; B. Bennett, personal communication).

The Woodchuck, *Marmota monax*, apparently has a broad range through the southern Yukon; however, sightings and specimens indicate a geographic separation of at least 370 km between the southern (Ross River; 61°59'N, 132°27'W) and central (Klondike; 63°39'N, 138°40'W) populations which Youngman (1975) shows as contiguous.

The Least Chipmunk, *Neotamias minimus*, was reported by Youngman (1975) at Bonnet Plume Lake. It has since been sighted approximately 100 km northwest on the Bonnet Plume River (seven locations from Bonnet Plume Lake to Fairchild Creek (64°58'N, 133°46'W; B. Slough, unpublished data) and approximately 80 km northwest on the Wind River (65°03'N, 134°54'W; S. Gilbert, personal communication). The species appears well distributed in the Wernecke Mountains.

The distribution of the Ogilvie Mountains Lemming, *Dicrostonyx nunatakensis*, is poorly understood, since it is known from only 13 specimens collected at Angelcomb Peak in the Ogilvie Mountains (64°36'N, 138°16'W; Youngman 1964, 1967, 1975), two of which were recorded recently (T. Jung and B. Slough, unpublished data).

Krebs and Wingate (1976, 1985) captured Nearctic Brown Lemmings, *Lemmus trimucronatus*, near the Alaska Highway south of Kluane Lake and from the Chilkat Pass, near the Haines Road, in British Columbia, extending its known range about 170 km southwest of that reported by Youngman (1975).

The Singing Vole, *Microtus miurus*, is known at present only from the British Mountains, the southern Ogilvie Mountains, and from the Kluane region of the southwestern Yukon (Youngman 1975; Krebs and Wingate 1976, 1985). Krebs and Wingate (1976, 1985) trapped extensively in the Kluane region and found the southern limit of distribution to be the Slims River area at the south end of Kluane Lake (61°N, 138°31'W). Nagorsen (2002) reported that it has not been found south to the British Columbia border as suggested by Banfield (1974) and Youngman (1975).

Jung et al. (2006b) reported the Southern Redbacked Vole, *Myodes gapperi*, from the Yukon at the La Biche River (60°08'N, 124°04'W). Youngman (1975) did not report *M. gapperi* from the Yukon; however, he considered *M. gapperi* and the Northern Red-backed Vole (*M. rutilus*) to be conspecific. Based on the distribution of *M. gapperi* in adjacent northeastern British Columbia and southwestern Northwest Territories (Banfield 1974; Nagorsen 2005) we suspect that *M. gapperi* may be more widespread in the Liard River watershed.

Youngman (1975) gave the northwestern limit of the Bushy-tailed Woodrat, *Neotoma cinerea*, as Kluane Lake. It has since been been observed on Ogilvie Island, Yukon River, near Youngman's projected northern limit (63°34'N, 139°44'W; B. Bennett, personal communication). In 2003, a nest of this species was observed at Bear Creek (64°02'N, 139°15'W; B. Slough, unpublished data), representing a 160 km northward range extension.

Muskrat, *Ondatra zibethicus*, inhabit wetlands across the territory (Youngman 1975). The northernmost observations were made in the Arctic wetlands of the Mackenzie Delta in the Yukon (68°46'N, 136°32'W; B. Slough, unpublished data).

The Northwestern Deermouse, *Peromyscus keeni*, had been confirmed through DNA analysis as being present in the Coast Mountains and adjacent areas of the southwestern Yukon (Wike 1998; Lucid and Cook 2004; M. Lucid, personal communication) within the range of the former *P. maniculatus algidus*.

In July 2005, a North American Deermouse, *P. maniculatus*, was captured in the Ogilvie Mountains (64°30'N, 138°13'W; T. Jung et al. unpublished data); representing a 70 km northward range extension, but within the range projected by Youngman (1975).

Interestingly, Lucid and Cook (2007) provide DNA evidence of an undescribed species of *Peromyscus* in southwestern Yukon. Wike (1998), working in central Yukon, also reported the possibility of an undescribed species of *Peromyscus* in the Yukon.

Banfield (1974) and Youngman (1975) show the Northern Bog Lemming, *Synaptomys borealis*, ranging throughout the Yukon north to the Porcupine River drainage. Smits et al. (1989) reported *S. borealis* teeth

and bone fragments in the scat of an Arctic Fox, *Vulpes lagopus*, collected in 1985, on Herschel Island, extending the range of *S. borealis* about 150 km north to the Beaufort Sea (69°35'N, 139°05'W).

The Western Jumping Mouse, *Zapus princeps*, is known from only two specimens collected in 1944 (Rand 1945; Youngman 1975) and another collected in 1980 (S. Beare, unpublished data); all three specimens are from the South Canol Road, near the Rose and Nisutlin rivers.

Order Carnivora (Carnivores)

Sixteen species of carnivores, representing four families (Canidae, 4 species; Ursidae, 3 species; Mustelidae, 7 species; Felidae, 2 species), are recorded from the Yukon (Table 1).

Coyotes, *Canis latrans*, expanded northward from 55°N to southern Alaska between 1829 and 1907 (Banfield 1974). The earliest reported sighting for the area is from "near Whitehorse, on the Alsek River Alaska, in February 1907" (J. A. Allen 1908, reported in Hall 1981). Cairnes (1909) reports the presence of Coyotes in the southern Yukon in 1908. The range has been represented as the entire Yukon (Banfield 1974; Youngman 1975); however, trapper and hunter returns and observations suggest that Coyotes are absent or scarce north of 65°N (Yukon Department of Environment, unpublished data). Extraordinary observations, such as a sighting at Old Crow (67°N, 135°W, C. P. Charlie reported in Youngman 1975) should be considered as extra-limital and not evidence of range expansion.

The Arctic Fox, occurs on the Yukon Coastal Plain and Herschel Island, roughly northward of the 150 m ASL contour (Smits and Slough 1993). There is no evidence of denning or other range use further inland, therefore extraordinary specimens from the Old Crow Flats and the Porcupine River (reported in Youngman 1975) should be considered as extra-limital and not evidence of range expansion. Similarly, extraordinary observations of Polar Bear, *Ursus maritimus*, near Old Crow (reported in Youngman 1975) should be considered as extra-limital and not evidence of range expansion. The Yukon range of Polar Bears is also restricted to the North Coastal Plain and Herschel Island.

An analysis of fur harvest data from registered traplines to 2006 shows that the Fisher, *Martes pennanti*, is largely confined to the Liard River watershed in the southeast Yukon, ranging west to the Teslin River (60°28'N, 133°18'W) as projected by Youngman (1975). Youngman's northern limit was approximately 61°N; however, the species ranges 80 km north to 61°40'N (upper Hyland River and Finlayson Lake; B. Slough and T. Jung, unpublished data). Several observations have been made west of the Teslin River, and Fishers have been trapped north of Whitehorse (Klusha Creek; 61°13'N, 135°58'W) and near Haines Junction (60°51'N, 137°36'W). We believe that the species is expanding its range northwards and westwards.

The Least Weasel, *Mustela nivalis*, occurs throughout the Yukon (Banfield 1974) and, contrary to Youngman (1975), it is present in the Liard watershed. Individuals have been captured by trappers in the Liard watershed (B. Slough, unpublished data; Yukon Department of Environment, unpublished data).

American Mink, *Mustela vison*, occurs throughout the Yukon, as far north as the Old Crow Flats (Youngman 1975) where it has been captured by trappers (Yukon Department of Environment, unpublished data) but does not appear to be a regular inhabitant north of the treeline (68°25'N; Bee and Hall 1956; Banfield 1974) as suggested by Youngman (1975).

Similarly, the North American River Otter, *Lontra canadensis*, occurs throughout the Yukon, as far north as the British and Richardson mountains (Youngman 1975), but does not likely inhabit the Arctic Coastal Plain (north of the 150 m ASL contour, Bee and Hall 1956; Banfield 1974) as suggested by Youngman (1975). We suggest that an observation from Herschel Island (Wildlife Management Advisory Council (North Slope) and the Aklavik Hunters and Trappers Committee 2003*) was an extra-limital movement. A similar occurrence was reported for the Beaufort Sea of northeastern Alaska by Haskell (2006). Additionally, we suggest that the Arctic range for Canadian Lynx, *Lynx canadensis*, shown by Youngman (1975) is extra-limital, and occurs only following years during a population crash.

The range of Cougar, *Puma concolor*, in the Yukon remains somewhat obscure, given the species' propensity for long-distance extra-limital movements. Sporadic sightings have occurred throughout the southern half of the territory. Although most sightings are unsubstantiated, they occasionally occur in concurrent geographic clusters and are often associated with the occurrence of Mule Deer, *Odocoileus hemionus*, (Yukon Department of Environment, unpublished data), providing some credibility to the sighting data. The first Yukon specimen was found dead at Watson Lake (60°04'N, 128°43'W) in November 2000 (Jung and Merchant 2005). Successful breeding by *P. concolor* in the Yukon has not been documented.

Order Artiodactyla (Even-toed Ungulates)

Ungulates have long been the management priority in the Yukon, and consequently the best known Order. Nine species of ungulates, representing two families (Cervidae, 5 species; Bovidae, 4 species), are recorded from the Yukon (Table 1). Since Youngman's (1975) review, White-tailed Deer, *Odocoileus virginianus*, have been recorded in the Yukon (Hoefs 2001).

Since Youngman (1975), introduced populations of Elk, *Cervus elaphus*, north and west of Whitehorse have grown substantially and now may number over 200 animals, although no reliable estimates are available. In addition to introduced populations, Elk have been reported regularly since 1977 in southeastern Yukon, primarily in the Hyland, Beaver, Coal, La-

Biche, and Liard river valleys (Hoefs et al. unpublished data*). The most recent reported location in southeast Yukon is from October 2004 at Beaver River, where the resident trapper has seen Elk with some regularity over the past several years (60°'N, 124°25'W; D. MacDonald, personal communication). Whether these animals in the southeast represent populations expanding their range northward from British Columbia (Shackleton 1999), or are extra-limital movements, is unknown.

Mule Deer, *Odocoileus hemionus*, appear to have extended their range in the Yukon since the review by Youngman (1975). They are now found throughout the Yukon, south of the Ogilvie Mountains (64°05'W) and including westward to Alaska (Hoefs 2001). Hoefs (2001) reported a 1998 observation north of the Ogilvie Mountains at Chapman Lake (64°50'N, 138°25'W). We regard this observation, however, as an extra-limital movement and not evidence of Mule Deer being distributed north of the Ogilvie Mountains.

Reliable observations of White-tailed Deer, *Odocoileus virginianus*, some including photographs, have been made in the Yukon (Hoefs 2001). The first observation was reported in 1975 near Tagish Lake (60°10'N, 134°20'W, Hoefs 2001). Mayo (63°05'N, 135°53'W) appears to be the most northern location that White-tailed Deer have been observed in the Yukon (M. O'Donoghue, personal communication). Hoefs (2001) reported an antlered skull found near Ross River (62°N, 132°25'W) as further evidence of White-tailed Deer in the Yukon.

American Bison (*Bison bison*) (Wood Bison subspecies, *B. b. athabascae*) have been reintroduced to the Yukon since the review by Youngman (1975). An attempt in 1951 to establish a small herd of Plains Bison, *B. b. bison*, in the Yukon, by releasing five animals from Alaska, had failed (Youngman 1975). Three Wood Bison herds may now be found in the Yukon; all are reintroduced. The Aishihik Herd ranges in southwestern Yukon, near Aishihik Lake (61°36'N, 137°30'W). Two other, smaller herds – the Nahanni and Nordquist herds – mainly range in the Northwest Territories and British Columbia; Shackleton 1999), respectively, but a portion of their annual range is in southeastern Yukon. The Nahanni Herd ranges into the LaBiche River valley (60°07'N, 124°03'W); the Nordquist Herd ranges along the Alaska Highway, north of Liard Hot Springs in British Columbia, and into the Yukon at Contact Creek (60°01'N, 127°37'W). Both of the southeastern herds were also reintroduced to their native range in the 1990s (Gates et al. 2000).

Muskox, *Ovibos moschatus*, were reintroduced to Barter Island (70°08'N, 143°38'W) and the adjacent mainland in northern Alaska in 1969 and 1970. Muskox were sighted almost yearly in the Yukon since the reintroduction but they did not appear to establish a year-round breeding population at the time of Youngman (1975). The first mixed sex groups including calves were reported in the Yukon in 1986 (D. Cooley, personal communication). They currently range as far east as the Blow River (ca. 137°W; D. Cooley, personal communication). Summer movements to the Old Crow Flats (ca. 68°N, 140°W) have been somewhat common since 1995. A new resident breeding population appears to have formed in the Richardson Mountains (ca. 68°N, 137°W) that remains all year in the mountains (D. Cooley, personal communication).

Hypothetical Species

The following species are found in neighbouring Alaska, British Columbia or the Northwest Territories, and their ranges may extend into the Yukon (Table 2). Some taxa, such as shrews and bats, are undersampled, as are some of the more remote geographic areas.

The Alaskan Tiny Shrew, *Sorex yukonicus*, likely occurs in the Yukon (Table 2), but has yet to be collected outside Alaska. This species has been recently described from seven specimens from Alaska in 1993 (Dokuchaev 1997). Subsequently, other specimens (ca. 30) have been obtained from Alaska as a result of directed pitfall trapping efforts (Peirce and Peirce 2000; MacDonald and Cook 2001*; Cook and MacDonald 2003*), indicating that the species is widespread, but uncommon, in Alaska. Specimens were obtained from Yukon-Charley Rivers National Preserve and Wrangell-St. Elias National Park and Preserve only 50 km and 12 km, respectively, from the western Yukon border (MacDonald and Cook 2001*; Cook and MacDonald 2003*). Directed sampling effort in 2003 near the abandoned village of Fortymile (64°25'N, 140°32'W) failed to secure a specimen (B. Slough and J. Jung, unpublished data).

Youngman (1975) noted the Long-legged Bat, *Myotis volans*, as a hypothetical species for the Yukon, based on a record near Atlin, British Columbia, reported by Swarth (1936). The species was recently captured in the southwestern Northwest Territories (Lausen 2006*). In addition to *M. volans*, we add the Western Long-eared Bat, *M. evotis*, and Silver-haired Bat, *Lasionycteris noctivagans*, to the list of hypothetical bat species in the Yukon. All three of these hypothetical species have recently been captured within 150 km of the Yukon border in northeastern British Columbia (see: Wilkinson et al. 1995*; Bradbury et al. 1997*; Crampton et al. 1997*; Vonhof et al. 1997*; Vonhof and Wilkinson 1999*; Lausen 2006*) and occur in southeast Alaska (Parker et al. 1997). These captures, however, have not been substantiated with a specimen, echolocation recording or a genetic sample (D. Nagorsen, personal communication). Acoustic records also exist for the Hoary Bat, *Lasiurus cinereus*, and the Eastern Red Bat, *L. borealis*, from the southwestern Northwest Territories (Lausen 2006*), suggestive that these species may also occur in southeastern Yukon. Parker and Cook (1996) reported Keen's Myotis, *Myotis keenii*, from southeastern Alaska (north to ca. 58°N), and it may yet be reported from in or near Kluane National Park Reserve in southwestern Yukon.

TABLE 2. Hypothetical terrestrial mammals that may occur in the Yukon.

Order / Family	Scientific Name	English Common Name
SORICOMORPHA		
Soricidae	*Sorex yukonicus*	Alaskan Tiny Shrew
CHIROPTERA		
Vespertilionidae	*Lasionycteris noctivagans*	Silver-haired Bat
	Lasiurus borealis	Eastern Red Bat
	Lasiurus cinereus	Hoary Bat
	Myotis evotis	Long-eared Myotis
	Myotis keenii	Keen's Myotis
	Myotis volans	Long-legged Myotis
LAGOMORPHA		
Leporidae	*Lepus arcticus*	Arctic Hare
	Lepus othus	Alaskan Hare
RODENTIA		
Sciuridae	*Marmota broweri*	Alaska Marmot
Muridae	*Mus musculus*	House Mouse
CARNIVORA		
Memphitidae	*Mephitis mephitis*	Striped Skunk

In addition to the resident Snowshoe Hare, *Lepus americanus*, Youngman noted the possibility of Arctic Hare, *L. arcticus*, or Alaskan Hare, *L. othus*, being found in northern Yukon. There is an unsubstantiated sight record of *L. arcticus* from the eastern Richardson Mountains of the Yukon in the 1970s (P. Frankish, personal communication).

The Alaska Marmot, *Marmota broweri*, may occur in the Yukon, but it has not yet been recorded from there. *M. broweri* is found as far east in Alaska as the Brooks Range in the Arctic National Wildlife Refuge (Bee and Hall 1956); it may also range in the British Mountains in Ivvavik National Park, Yukon. The Wildlife Management Advisory Council (North Slope) and the Aklavik Hunters and Trappers Committee (2003*) reports "two people said they remembered seeing (marmots) in 1960s and 1970s in the Babbage and Firth River areas".

The House Mouse, *Mus musculus*, occurred in the vicinities of Dawson and Whitehorse in the 1970s (Youngman 1975); however, no further specimens have been obtained. This species may be periodically introduced, but does not appear capable of sustaining commensal populations in the Yukon.

Banfield (1974) shows the Striped Skunk, *Mephitis mephitis*, entering the Yukon in the extreme southeast (La Biche River region) and coming very close in the Teslin area. It has not been documented from the Yukon with the nearest record being two skins taken at the junction of the Fort Nelson and Liard rivers in British Columbia (Rand 1944; Hatler et al. 2008), about 52 km SE of the Yukon. In the Northwest Territories, it is present at Fort Smith, and is expected at Fort Liard (S. Carrière, personal communication), the latter being only 30 km from the Yukon border.

Conclusions

Knowledge of the diversity and distribution of the terrestrial mammals of the Yukon has improved steadily since the last review was published in 1975 (Youngman 1975). Excluding Humans, there are now 63 species of terrestrial mammals that are believed to occur in the Yukon, representing 40 genera, 15 families and 6 orders (Table 1). There are an additional 11 hypothetical species (Table 2). All species, except *Mus musculus*, are native. Only one species, *Dicrostonyx nunatakensis*, is endemic. Populations of some species native to the Yukon have been introduced (*Cervus elaphus*) or reintroduced (*Martes americana*, *Oreamnos americanus*, *Bison bison*).

The mammalian fauna of the Yukon is in a relatively dynamic state. Several species have colonized the Yukon in the past 125 years (e.g., *Canis latrans*, *Odocoileus hemionus*, and *Puma concolor*). The history of mammal colonization and evolution in Yukon and neighbouring Alaska have been discussed by Youngman (1975) and MacDonald and Cook (1996). Approximately one-third of the recent terrestrial mammals of the Yukon originated in Beringia; the remainder are southern immigrants (Youngman 1975). Many of the southern immigrants have limited distributions in the Yukon today. For example, the newly recorded bat species are likely southern immigrants, and Chiropterans may still be colonizing northwestern North America (Jung et al. 2006a). *Myodes gapperi* and *Peromyscus keeni* are similarly southern immigrants. Further cryptic species may be present in the Yukon, for example, in the genus *Peromyscus* (Lucid and Cook 2007) and *Myotis* (Jung et al. 2006a). Human-induced changes, particularly climate change, will undoubtedly affect mammalian diversity and distributions, particularly in

northern regions (e.g., Humphries et al. 2002, 2004). Ranges of some species in the Yukon will likely grow with anthropogenic habitat changes and climate warming (e.g., Mule Deer), while others may contract (e.g., Caribou). Detailed mapping of distribution in the Yukon can assist in monitoring any change in distributional patterns.

Appropriate sampling techniques for species typically undersampled, such as echolocation monitoring and mist-netting for bats and pitfall trapping of shrews, has rapidly increased our knowledge of these secretive and cryptic species in the Yukon. Sampling in remote areas not well surveyed for mammals will also likely yield interesting records. Further mammal surveys, particularly for the smaller species (<1 kg) and in geographic areas with inadequate sampling, will continue to improve our understanding of Yukon mammals. Such knowledge is imperative for the conservation of biodiversity and predicting the impact of climate change and landscape change on the diversity, distribution and conservation status of Yukon's mammals.

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State Records and Habitat of Clam Shrimp, *Caenestheriella gynecia* (Crustacea: Conchostraca), in New York and New Jersey

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We report new records of the Clam Shrimp, *Caenestheriella gynecia* Mattox 1950, from three localities in the Hudson Valley of New York and one locality in northeastern New Jersey. All of our specimens were collected in puddles on dirt roads. The New Jersey specimens have meristics that are well within the range of *Caenestheriella* Daday 1915; however, the eastern New York specimens resemble those reported from Massachusetts with meristics that are closer to *Cyzicus* Audouin 1837. We hypothesize that *C. gynecia* was established as a parthenogenetic species due to an unlikely dispersal event in the western part of its range and has migrated eastward since the last glacial maximum. Dispersal of this species may occur by wind, in the gut of birds, or stuck to animal feet or fur, or to vehicles. We recommend that *C. gynecia* be treated as rare and vulnerable to extinction throughout its range unless demonstrated otherwise.

Key Words: Clam Shrimp, *Caenestheriella gynecia*, temporary pond, biogeography, dirt road, New York, New Jersey.

Clam Shrimps are small freshwater bivalvular arthropods in the order Conchostraca. Clam Shrimps inhabit isolated ephemeral pools, temporary ponds, and sometimes lakes; the taxon is found nearly worldwide (Williams 1987). *Caenestheriella gynecia* Mattox 1950 is a parthenogenetic species with no records of males, although males can be uncommon in related species and may be discovered (see Eder et al. 2000). Until Smith and Gola (2001) reported two populations of this species from western Massachusetts, the known range extended east from Ohio (Smith 2001) to northeastern Pennsylvania. Here we report four localities of *C. gynecia* in the eastern United States, representing range extensions to New York and New Jersey.

Methods

Specimens were captured from rain puddles and preserved in 50% isopropanol. Preserved specimens were measured with digital calipers (greatest length in mm). Spines on the telson and second antennal segments were counted at 320× with a stereomicroscope.

Results

Here we document four collections of *Caenestheriella gynecia*, representing the first records of this species from New Jersey and New York.

New Jersey: rain puddles on unimproved Paterson Lateral Gas Pipeline road between Empire Avenue and the New Jersey Turnpike, Borough of Carlstadt and Township of South Hackensack, Bergen County, 74°02'26"W longitude, 40°49'37"N latitude, Hackensack Meadowlands. [Weehawken, New Jersey–New York. 1967, U.S. Geological Survey (USGS) 7.5 minute topographic map sheet], *E. Kiviat*, 2 September 2001. 6 specimens (Kiviat and MacDonald 2004).

New York: rain puddle on abandoned farm road, 3.5 km south of Rhinebeck, Dutchess County, 73°55'15"W longitude, 41°53'19"N latitude, Town of Rhinebeck, [Kingston East, New York. 1963, photorevised 1980 USGS 7.5 minute topographic map sheet], *S. Nyman*, 27 May 1994. 1 specimen, 7.6 mm, dried (Site C-3 in Kiviat et al. 1994*).

New York: rain puddles on dirt road, ca. 1.4 km NNW of East Park, Dutchess County, 73°55'20"W longitude, 41°48'19"N latitude, Town of Hyde Park, [Hyde Park, New York. 1963, USGS 7.5 minute topographic map sheet] *E. Kiviat & J. Bridges*, 26 June 2002. 5 specimens.

New York: rain puddles on ATV trail, ca. 3.4 km NNE of Saugerties, Greene County, 73°55'58"W longitude, 42°06'33"N latitude, Bristol Beach State Park [Saugerties, New York. 1963, USGS 7.5 minute topographic map sheet], *E. Kiviat,* 25 July 2007. 1 specimen.

Clam Shrimp habitats (Figure 1) at the New York and New Jersey localities were all rain puddles on dirt roads. Clam Shrimp were observed swimming slowly on the underside of the surface film in New Jersey, and swimming in the water column and along the bottom in New York. The puddles were ca. 1.5-30 m^2 and ca. 5-15 cm deep at the dates of collection. The rain puddles essentially lacked vascular plants. We have visited the puddles at the New Jersey locality several times at different seasons 2002-2007; some of the puddles maintained their depths even during dry periods, but did dry during the summer 2005 drought. The New Jersey puddles were consistently very turbid and Clam Shrimp were not visible below the surface; the Hyde Park pools were clear enough to see Clam Shrimp swimming along the bottom. The roads at the New Jersey and Saugerties, New York localities are regularly used by all-terrain

FIGURE 1. Habitat of *Caenestheriella gynecia* in New Jersey. Photograph by Erik Kiviat.

vehicles (including "four-wheelers" and motorcycles), and road vehicles (pickup trucks and sport-utility vehicles) were observed using the road at the Hyde Park locality. The puddles at the Bristol Beach State Park site were created and maintained by all-terrain vehicle use. We believe the puddle habitats at these four sites were created and maintained by wheeled vehicles; the puddles at the Rhinebeck locality appeared less recently disturbed and may have been created by farm vehicles. The dirt road at the Hyde Park locality was bordered by hardwood forest and woodland pools. The dirt road at the Rhinebeck locality was fringed by tall shrubs and small trees in the midst of a wet meadow and old field. In New Jersey, the dirt road was fringed by Common Reed (*Phragmites australis*), tall shrubs, and small trees, and was raised ca. 1.5 m above the level of extensive, formerly tidal, marsh now dominated by common reed. The ATV trail at the Bristol Beach site was bordered by second-growth hardwood forest.

The Hyde Park and Rhinebeck roads appear to comprise *in situ* soil materials which are mapped as Nassau-Cardigan complex (Lithic and Typic Dystrochrepts) and Sun silt loam on glacial till, and Hudson-Vergennes soil (Glossaquic Hapludalf) on glaciolacustrine silty clay, respectively (Faber 2002*). The Saugerties site has soils mapped as Hudson silt loam, a Glassaquic Hapludalf and Madalin silty clay loam, a Mollic Ochraqualf according to Tormes (1979*).

The pH of these soils varies from strongly or very strongly acidic at the surface to moderately akaline in the substratum (Faber 2002*). Wetlands adjoining the New Jersey site were mapped as Sulfhemists and Sulfaquents (Goodman 1995*); however, the dirt road appears to have been constructed from imported material with a light reddish color that may have originated from nearby red Triassic shale and sandstone (Schuberth 1968). We have not found Clam Shrimp in wetlands adjoining the dirt road habitats.

Smith and Gola (2001) discussed generic placement of this species and showed that the meristics on their Massachusetts specimens were not typical of *Caenestheriella* but were intermediate or closer to species of *Cyzicus* Andouin 1837. The most significant difference in the genera is the shape of the male rostrum which cannot be determined in our specimens. There are differences in the number of spines on the telson, but the counts on the Massachusetts specimens overlapped the genera and Smith and Gola (2001) questioned whether the two genera were distinct. The size and meristics of our New Jersey specimens (Table 1) fall clearly within *Caenestheriella* Daday 1915 (all specimens contained eggs) as did the single specimen from Saugerties (west of the Hudson River). Our New York specimens from east of the Hudson River, however, are similar to those in western Massachusetts. It is possible that the eastern New York and Massachusetts populations are *Cyzicus*.

Discussion

Caenestheriella gynecia inhabits temporary freshwater pools and was considered a "warm water" species

TABLE 1. Size and meristics of *Caenestheriella gynecia* (Clam Shrimp) specimens from New Jersey and New York.

State	Number of specimens	Mean (range) size, mm	Number of telson spines	Number of segments, 2nd antennae
New Jersey	6	4.75 (4.2-5.2)	18-22	15-19
New York	5	9.10 (8.6-10.2)	27-32	15-20

by Weeks and Marcus (1997). This is typical habitat for a suite of clam shrimp and relatives (Anostraca, Notostraca) and for certain distantly related species of Cladocera and Ostracoda (Williams 1987). The diversity of aquatic animals in a given pool is low, however, probably due to the habitat's inherent instability and simplicity. *Caenestheriella gynecia* appears to be different from its close and distant relatives in that it is known mostly from rain puddles on dirt roads; the type locality (Mattox 1950), a second location in Ohio (Emberton 1980), one of the populations in Massachusetts (Smith and Gola 2001), and this paper. Although the puddles in which we found *C. gynecia* are more-or-less permanent, their small size (and high turbidity in the case of the New Jersey pools) may exclude some aquatic predators much as does impermanence.

Wiggins et al. (1980) and Williams (1985) characterized the resident biota of ephemeral aquatic habitats as having high fecundity, short life spans, and rapid maturation. Additionally Clam Shrimp produce "resting eggs" (Hann 1996*) which can tolerate heat, cold, and dessication and may require freezing or drying to hatch (Mattox and Velardo 1950; Belk and Belk 1975).

Hann (1996*) observed that the small scale distribution of *Caenestheriella setosa* was patchy, with some puddles inhabited while nearby puddles were empty. This suggests that, despite the Clam Shrimp's investment in large numbers of resting eggs, egg survival is low, even short-distance dispersal is difficult, or local extinction (in a pool) is frequent. Boileau and Taylor (1994) showed that related organisms had poor dispersal over even very short distances and calculated that there were 0.6-4.5 dispersers per generation in small pools in South Carolina. We presume that dispersal of Clam Shrimp is primarily in the resting egg stage and we can envision several modes of dispersal of these eggs.

Eggs of *C. gynecia* from desiccated puddles could be blown along with soil particles from one puddle or locality to another. Animals passing through puddles, especially species that spend time in muddy habitats, could pick up eggs in mud adhering to their feet, shells, or fur. Potential vectors of dispersal include Raccoons (*Procyon lotor*, see Maguire 1963), Mallards (*Anas platyrhynchos*), Snapping Turtles (*Chelydra serpentina*), and humans. More recently, human traffic in the form of wheeled or tracked vehicles could act as a dispersal agent.

Although our few specimens of *C. gynecia* do little to establish a pattern that would resolve the taxonomic question posed by Smith and Gola (2001), there is a geographic pattern that deserves discussion. All known localities for this species are within the maximum extent of the Wisconsinan glaciation (Figure 2) except one location in central Ohio (Emberton 1980). It is, of course, possible that not all populations of this species have been documented (especially since we are here reporting several) and that there may be populations to the south of the known distribution. This is important because robust biogeographic hypotheses do require accurate knowledge of an animal's distribution. Although this species is rare, there are a number of researchers actively working with Clam Shrimp in the midwestern and southern United States and there have been no other reports of this species.

This distribution suggests the following hypotheses. *Caenestheriella gynecia* is derived from a sexually reproducing species, probably *C. setosa*, whose range is closest to *C. gynecia*. Dispersal into the glaciated area occurred in the Ohio Valley and was an unlikely event given the dispersal mechanisms of the species. Unlikely dispersal would favor establishment of a parthenogenetic individual over at least two sexually reproducing ones. This scenario suggests that *C. gynecia* is relatively young, less than 12 500 years old (the approximate age of the last glacial retreat).

Dispersal eastward from the Ohio Valley would be equally unlikely except that seasonally muddy dirt roads were created soon after European colonization of the northeastern states. *Caenestheriella gynecia* could have spread as eggs in mud splattered on wagons or horses' hoofs and its distribution would follow traffic flow. Recently, many of these colonial roads have been paved, leaving *C. gynecia* to persist in the remaining dirt road habitats, including farm roads, logging roads, and service roads for powerlines and pipelines.

The above scenario could be corroborated by phylogenetic and genetic analyses. The closest living relative of *C. gynecia* should be geographically very close to *C. gynecia* but we are unaware of any phylogenetic analyses of this genus. Additionally, the genetic variation in *C. gynecia* should be minimal because it is parthenogenetic, has been derived from a very small founder population, and is geologically young.

Caenestheriella gynecia or its ancestors could have evolved in association with American Bison (*Bison bison*), living in "buffalo wallows" and dispersing in mud caked on Bison fur or hoofs. Butler (1995) noted buffalo wallows somewhat larger than the puddles where we collected *C. gynecia* and alluded to observations of mud stuck to fur. Dispersal of resting stages in the guts of birds is also possible for *C. gynecia*. Proctor et al. (1967) found that *Artemia* eggs and the eggs and adults of Ostracoda could remain viable after passing through the gut of Killdeer (*Charadrius vociferus*).

FIGURE 2. Map of the eastern United States showing collection localities of *Caenestheriella gynecia* in relation to the southern extent of the most recent glaciation.

Long distance (1400 km) dispersal of *Caenestheriella belfragei* was presumed due to eggs being carried on or in waterfowl (Donald 1989). Proctor (1954) showed that viable eggs of some phyllopods could pass through the gut of ducks. If *C. gynecia* had been carried to the glaciated areas by waterfowl, its close relatives could be anywhere along the waterfowl flyways.

Two of the New York and the New Jersey Clam Shrimp localities are privately owned. The Hyde Park road is part of a residential subdivision and reportedly has been excavated for installation of a water pipeline. The New Jersey road is subject to gas pipeline maintenance activities and adjoins The Richard P. Kane Natural Area, possibly subject to habitat restoration. Because field surveys have not been conducted to determine the distribution of, and degree of threat to, *C. gynecia* populations in the northeastern states, we recommend this species be treated as rare and vulnerable to extinction unless demonstrated otherwise. Only 11 localities (Figure 2) have been reported for *C. gynecia*, including our localities, although a recent Ohio survey listed just one site (Weeks and Marcus 1997). If this Clam Shrimp were reviewed by state Natural Heritage Programs in New York and New Jersey it would be ranked as G2, S1 assuming all the reported sites are extant. We recommend that dirt roads one year or more old with long-lasting rain puddles > 1 m^2 and > 5 cm deep be checked for Clam Shrimp during June-September as part of land management or environmental review processes. Clam Shrimp may sometimes be observed swimming in the pools and may be captured by sweeping a fine-mesh dipnet through the pools.

Research, conservation, management, and restoration of biodiversity are most often done in wildlands and natural areas. Yet urban, industrial, and other altered landscapes are expanding rapidly in North America. Certain rare or declining native species survive or even thrive in human-altered landscapes. Examples of rare species occupying human-disturbed soils are: Knieskern's Beaked Rush (*Rhynchospora knieskernii*) in a tire rut and on a waste dump in the New Jersey Pine Barrens (Schuyler 1999) and larvae of the Regal Fritillary (*Speyeria idalia*) overwintering in soils disturbed by tanks in Pennsylvania (Rosenzweig 2003). These ecological distributions can be the result of human activities creating a surrogate habitat type or physical-chemical environment not otherwise available, an abundance of food, reduced predation or competition, or persistence during landscape change (see, e.g., Adams 1994). It can be said that "Biodiversity is where you find it." Therefore conservation biologists and environmental planners need to pay more attention to organisms such as *Caenestheriella gynecia* and the artificial or altered habitats that support them. Altered or artificial habitats of types known to support rare organisms should be surveyed for those species routinely, much as natural and semi-natural habitats are surveyed for rare species. Those sites discovered to support a rare

species, such as the Clam Shrimp sites reported here, should be considered for conservation management. In the case of *Caenestheriella gynecia*, management may need to include a degree of controlled motor vehicle activity or its equivalent to maintain the puddle habitat and potentially disperse Clam Shrimp among puddles. We recommend that this species be considered rare and vulnerable to extinction throughout its range unless demonstrated otherwise.

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Colonization of Non-Traditional Range in Dispersing Elk, *Cervus elaphus nelsoni*, Populations

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As ungulate populations increase in density on traditional range, resulting increases in intraspecific competition can encourage dispersal of some individuals to new areas. Such areas, although lower in density of conspecifics, might present unfamiliar arrays and types of habitat that could require altered patterns of home range and habitat use by dispersers. However, the specific adaptations employed by dispersers in such circumstances are not well documented or understood. I investigated three cases of range expansion by Elk (*Cervus elaphus nelsoni*) populations experiencing population growth on traditional ranges in south-central Montana, USA. Each source population produced a group that dispersed to non-traditional areas. Compared to source populations, dispersing groups increased average size of home ranges, changed patterns of use in core areas of home ranges, and used habitats differently than Elk on traditional range. Dispersing groups demonstrated fidelity to new ranges equal to that of source populations, but their seasonal tenure on non-traditional range was strongly linked to environmental conditions, especially rainfall. Dispersal of groups increased the overall range of the population and its range of habitat use. In growing populations of Elk, managers should determine if dispersing groups exist and whether they should be protected to establish new populations in marginal areas or be reduced to limit potential Elk-landowner conflicts.

Key Words: Elk, *Cervus elaphus*, dispersal, habitat use, population, Montana.

On traditional ranges, animals typically concentrate use in the most productive patches of habitat (Charnov 1976; Parker and Stuart 1976). However, intraspecific population pressure, often associated with population growth, can cause a species to increase its range of habitat use in less predictable ways (Rosenzweig 1991). For non-territorial species, the tendency to increase range of habitat use with increasing population density has been formalized as the Ideal Free Distribution (IFD) Theorem. The Ideal Free Distribution Theorem asserts that individuals choose habitats at densities associated with equal levels of fitness (Fretwell and Lucas 1970). Thus, IFD predicts that when populations occupy new ranges at low densities, individuals will occupy only optimal habitat. As density increases, so does interference with conspecifics, causing individual fitness to decline. Individuals leave optimal habitat when fitness drops below what they could achieve in a suboptimal habitat at a lower population density.

Among ungulates, the behavior of Elk (*Cervus elaphus nelsoni*) in populations experiencing long-term population growth corresponds to predictions of IFD. Dispersive behavior associated with population growth and an increasing range of habitat use might contribute to the initial stages of colonization and the establishment of a permanent population in a previously unoccupied area (Safriel and Ritte 1983). The colonization of vacant habitat without decreased fitness of colonists is an alternative to increased intraspecific competition on traditional range. Although the IFD Theorem makes density-dependent dispersal theoretically plausible, such dispersal has been difficult to demonstrate in ungulates (Clutton-Brock et al. 1985; Boyce 1989), and determination of the mechanisms of colonization by individuals dispersing from established ungulate populations, or their relation to population growth, has been problematic.

In three increasing populations in south-central Montana, USA, Elk demonstrated changes in habitat use and home-range characteristics, increasing spatial separation of adjacent populations, and fissioning of individual populations into multiple populations (Van Dyke and Klein 1996; Van Dyke et al. 1998), all of which can lead to an increasing range of habitat use. The last response, population fissioning, was initiated by the formation of a dispersing group that made seasonal movements to new range, often containing a distribution of vegetation communities different from the traditional range of the established population. In investigating the role of such groups in expanding range and habitat use of established populations, I sought to determine what changes dispersing Elk make in their use of home range and habitats compared to their populations of origin that might enable them to persist on new ranges that the established population did not use.

Study Area

Three populations of Elk in south-central Montana (USA) were investigated, locally known as the Line Creek (LC), Picket Pin (PP), and Silver Run (SR) populations (Van Dyke and Klein 1996; Van Dyke et al. 1998).

These populations summer in the Absaroka-Beartooth Wilderness Area and winter in lower elevation foothills and prairies on the Custer National Forest and adjoining private land (Figure 1).

Climate in this area was characterized by long, cold winters and short, cool summers during the study period. Mean January and July temperatures at the Mystic Lake, Montana, reporting station (elevation 2339 m) near the approximate center of the study area were -4.1 and 17.1°C, respectively. Average annual rainfall and snowfall reported at the same location were 64.7 and 497.9 cm, respectively (NOAA 1992).

Forests were dominated, from lowest to highest elevations, by Limberpine (*Pinus flexilis*), Lodgepole Pine (*P. contorta*), Douglas Fir (*Pseudotsuga menziesii*), Engelmann Spruce (*Picea engelmannii*), and Whitebarked Pine (*Pinus albicaulis*). Non-forested communities at lower elevations were dominated by Bunchgrass (*Pseudoroegneria spicata*)-forb and sagebrush (*Artemisia* spp.) associations. Alpine areas were dominated by sedges (*Carex* spp.), cottongrass (*Eriophorum* spp.), Alpine Bluegrass (*Poa alpina*), and various alpine forbs. Detailed descriptions of these plant communities are provided in Van Dyke et al. (1991) and Van Dyke et al. (1994).

Methods

Sampling Procedures

Thirty-five female Elk were captured and radio-collared in January-March 1988 (19), December and February 1989 (11), March 1990 (1), and March 1991 (4). All but three were captured by darting from a helicopter (Nielson and Shaw 1967) with Carfentanil (dosage 0.0082 mg/kg). Two Elk were captured in baited traps and one Elk by a net-gun fired from a helicopter. All were fitted with telemetry collars (AVM Instrument Co., Telonics, Inc.). Procedures associated with locating individual animals have been described (Van Dyke and Klein 1996; Van Dyke et al. 1998).

Detection of Dispersing Groups

I documented movements of small groups (≤40 individuals) away from source populations (120-160 individuals) through relocations of ≥1 radio-collared Elk in each group. Such groups used different ranges and remained isolated from individuals in the source populations for 6-9 months each year. One group separated from each source population. These were the Trout Creek (TC) group from the PP population, the Hellroaring (HR) group from the SR population, and the Wolf Creek (WC) group from the LC population.

The relationship of dispersing groups to source populations, as well as the boundaries of seasonal ranges of the dispersing groups, was unknown prior to the study. As a result, individuals in dispersing groups were unintentionally collared when they were near source populations on winter range. Although only a small number of Elk were radio-collared in each group, the percentages of radio-collared Elk in such groups were ≥ those collared in source populations (5-12% vs. 4-6%, respectively). Given the sociability of Elk, previous studies have been successful in tracking large groups even when only one radio-collared animal was present (e.g., Craighead et al. 1973), and that also was the case in this study. Locations of radio-collared individuals were considered representative of the entire group because: (1) dispersing groups contained few (7-40) individuals; (2) dispersing groups remained constant in size during occupancy on non-traditional range, indicating that groups possessed a high degree of cohesiveness; and (3) radio-collared individuals always were present in the group when they were located.

Estimation and Analysis of Home Range Characteristics

Home range of each population or group was defined as the 95% contour minimum convex polygon (MCP) area and associated activity centers of source populations and dispersing groups as computed by HOME RANGE, a home range analysis program (Ackerman et al. 1990). To estimate seasonal home ranges, seasons were defined as winter-spring (1 December – 31 May) and summer-autumn (1 June – 30 November). Seasons were combined in this manner because source populations had substantial overlap between winter and spring ranges and between summer and autumn ranges (Van Dyke and Klein 1996; Van Dyke et al. 1998).

Because MCPs are sensitive to sample size, I evaluated only populations with ≥ 21 locations/season for calculation of seasonal range and ≥ 45 total locations for calculation of annual range. All samples were equal to or larger (seasonal $\bar{x}$ = 97, range 21-438; annual $\bar{x}$ = 189, range 45-787) than these minimums. Previous tests of the relation between numbers of locations and home area estimates indicate that such sample sizes estimated ≥ 81% of population home ranges for ungulates in this area (Van Dyke et al. 1995; Van Dyke et al. 1998). Core areas within home ranges (Kaufman 1962) were identified by comparing actual range use distributions generated from harmonic mean estimates of home range (Dixon and Chapman 1980) to hypothetical uniform use distributions (Samuel et al. 1985). I also determined the percent contribution of core areas to total home areas and core area percent contribution to total use, and then determined the ratio of use contribution to area contribution as an index of the concentration of use in core areas.

Evaluation of Range Use

Home areas of dispersing groups and source populations were compared in four ways. First, as a first approximation of potential movement differences in landscape pattern and scale, I compared distances Elk in dispersing groups moved from winter to spring or summer ranges with the same movements in their associated traditional populations using linear, straight-line distances between seasonal geometric activity centers in each group as determined by pooled locations from 1988-1992. I compared distances associ-

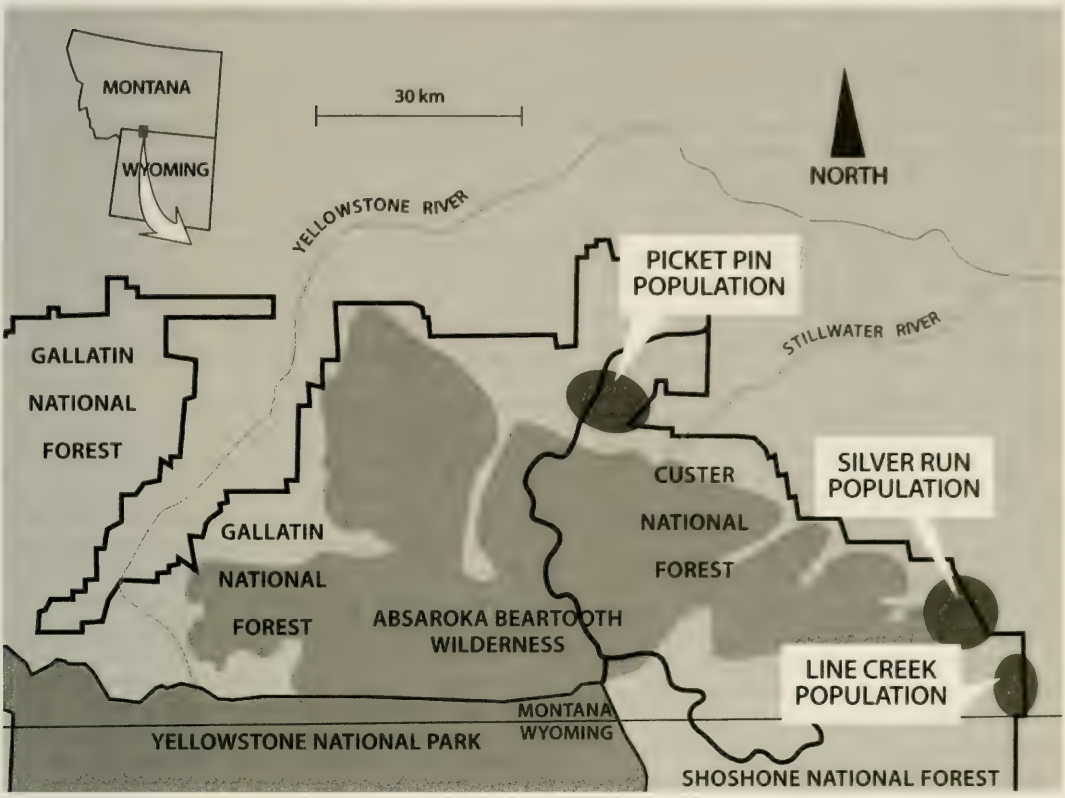

FIGURE 1. Study area and approximate ranges of the Line Creek, Picket Pin, and Silver Run populations of Elk in south-central Montana, USA, 1988-1991.

ated with such movements to the radius of the shared winter home area as an index of relative movement scale. Second, I compared home range size between source populations and dispersing groups using 2-sample *t*-tests. Third, I evaluated Euclidean distances between points in associated dispersing group and source populations through a multiple range permutation procedures test, which evaluates whether distributions of distances in different groups come from a common probability distribution (Mielke et al. 1976). Fourth, I compared use-area ratios of core areas between dispersing groups and associated source populations to determine if differences existed in degree of concentration of core area use using a 2-sample *t*-test. The ratio of core to non-core use is important because core areas would be likely to include the most optimal habitat within a home range. Therefore I treated the concentration of use in core areas as an index of relative differences between optimal and suboptimal habitats within a home range.

Use of Vegetation Communities and Production of Forage

The types of vegetation communities present on all seasonal ranges of all populations varied, but were simplified for analysis to categories of alpine, grass-forb (meadows), Douglas Fir, Limberpine, Lodgepole Pine, sagebrush, Spruce (subalpine forest), and Whitebark Pine. Together, these vegetation communities covered the range of elevations used by all populations in all seasons as well as broadly covering the array of vegetation communities encountered and used by Elk. Comparisons of use of vegetation communities by Elk in source populations, based on locations of animals, to availability of such communities visually identified at 568 randomly selected points within home areas of such populations were evaluated using the Design I version of Manly et al. (2002) resource selection function (RSF) model. This version of the RSF model, which uses independently sampled counts of available and used resources, assumes that the availability of vegetation communities does not change over the course of the study period, that vegetation communities were correctly identified, and that Elk had free and equal access to all vegetation communities within their designated ranges, assumptions that were met in this study. The model's null hypothesis that Elk select vegetation communities in proportion to their occurrence was tested by comparing use to availability via a Chi-square goodness of fit test (Manly et al. 2002). The application of this procedure to similar tests for random selection of

each vegetation community was adjusted using Bonferroni corrections to prevent error accumulation. I used Manly's standardized selection ratio to represent relative strength of selection for a given vegetation community. Vegetation communities with 0 availability in a given range were omitted from analysis.

Locations of Elk during 1988-1991 were used to determine core foraging areas of dispersing groups on summer ranges. Using radio telemetry locations and visual observation, I established five 404-m^2 (20.1 m × 20.1 m) macroplots selected within core foraging areas determined in each dispersing group and in the core foraging area of the PP population in 1991. Ten macroplots already had been established in core foraging areas of LC and SR populations (five in each area) as part of another study (Van Dyke et al. 1994). I compared volumes of forbs and graminoids produced from each core area associated with dispersing groups to core areas of respective source populations through 2-sample *t*-tests. Sampling methods have been described (Van Dyke et al. 1991, 1994). Shrubs were not included in the analysis because shrub coverage was low on most plots and summer diets of Elk in all populations averaged <10% shrubs (Van Dyke et al. 1994). Although species-specific forage selection was evident (Van Dyke et al. 1994), all available graminoids and forbs were consumed. Thus, estimates of forb and graminoid volume were considered to represent volume of edible browse.

Results

Seasonal dispersal and home range characteristics

All dispersing groups moved greater absolute and relative distances from winter to spring or summer ranges than traditional populations, and, in two of three cases, traveled in entirely different directions and followed different elevational gradients (Table 1). Relative to the size of winter home areas, traditional populations migrated distances 2.3-7.5× the radius of their winter home areas to reach spring and summer ranges, but dispersing groups moved 5.6-11.0× the radius of their winter home areas to reach new, non-traditional ranges in the same seasons.

Elk in dispersing groups used annual or seasonal ranges differently than Elk in associated source populations (Table 2). Differences also existed in home range sizes of dispersing groups and source populations (Figure 2). The annual and seasonal home ranges of Elk in the TC and WC groups were larger than home ranges of Elk in associated source populations. In contrast, seasonal home ranges of Elk in the HR group were similar to those estimated for individuals in the associated source population. Differences between source and dispersing group populations also were evident in use of core areas (Figure 3). Hellroaring Elk made greater use of smaller areas (higher use/area ratios) in summer and autumn than did Elk in their source (SR) population. A similar trend was evident in the more concentrated use of winter and spring core areas by the WC group. In contrast, the TC group demonstrated more dispersed range use than its source (PP) population, and had no identifiable core area in winter-spring (use/area ratio = 1).

Patterns of habitat and elevation use in source populations: Comparisons of source populations and dispersing groups

No population showed random proportional selection of vegetation communities ($P < 0.001$, all cases), but selection patterns differed in different populations, and, in two of three cases, patterns of selection in source populations differed from selection patterns in associated dispersing groups. The SR source population and HR dispersing group were the only source population-dispersing group pair in which selection of vegetation communities did not differ. Both used alpine areas less frequently than expected and used Lodgepole Pine communities more than expected (Table 3). The Line Creek source population and its associated WC dispersing group differed in selection patterns in four of seven vegetation communities (Table 4), and the PP source population and its TC dispersing group in four of eight (Table 5), although patterns were different in each case. Wolf Creek Elk used sagebrush communities most commonly in the spring, followed by an intensive shift to alpine communities in the summer, resulting in nearly equal rates of use in these communities over the combined period. However, WC Elk did not use any one vegetation community differently than expected, although their overall pattern of use was different from availability. In contrast, LC Elk made more equitable use of all available vegetation types, although they were most commonly located in stands of Limberpine (33%). Line Creek Elk used grass-forb and Limberpine communities more than expected, and sagebrush and alpine communities less than expected. Actual proportional use in grassland-forb communities was identical in the two populations. Observed differences in significance in this case were attributable to differences in the number of observations in the two groups.

The majority of PP Elk locations were in grass-forb vegetation (56%), and this population used this vegetation type and Limberpine at greater than expected frequencies. Picket Pin Elk used Lodgepole Pine less than expected. In contrast, TC Elk were most commonly located in stands of Douglas Fir (42%). They used this vegetation community more than expected, but used spruce-dominated vegetation less than expected.

Core foraging areas of dispersing groups and source populations differed in volumes of forbs and graminoids produced (Table 6). Trout Creek core areas had higher volumes of graminoids and forbs compared to PP core areas, but differences in other comparisons displayed no consistent pattern.

Two dispersing groups, TC and WC, showed different patterns in seasonal elevational use compared to their source populations (Figure 4). Trout Creek

TABLE 1. Scale considerations in distance, direction, and elevational differences in pairs of traditional source populations and dispersing groups of Elk in south-central Montana, U.S.A., 1988-1991. In each pair, the traditional source population is listed first. Migration distance (km) reflects distance from shared winter range activity center to traditional source population or dispersing group spring or summer range. Home range radii estimated as square root of home range area (km²) divided by π.

Population	Migration distance	Migration direction	Elevation change	Population home range radius – winter
Line Creek	4.9	W	Higher	2.12
Wolf Creek	11.8	NE	Lower	
Picket Pin	11.6	W	Higher	1.54
Trout Creek	17.0	NE	Same	
Silver Run	11.8	SW	Higher	1.70
Hellroaring	14.6	SW	Higher	

TABLE 2. Results of Multiple Range Permutation Procedures analysis comparing range utilization between dispersing groups and associated source populations in south-central Montana 1988-1991. $P < 0.05$ interpreted as evidence of significantly different distributions between dispersing group and associated source population. n = number of Elk locations used in analysis (source population and dispersing group, respectively). Seasons selected represent periods of movement to new ranges by dispersing groups.

Population	Season	n	Standardized test statistic	P
Picket Pin-Trout Creek	Annual	348/71	-102.89	<0.0001
Silver Run-Hellroaring	Summer-Autumn	291/58	- 46.24	<0.0001
Line Creek-Wolf Creek	Spring-Summer	263/73	- 10.99	<0.0001

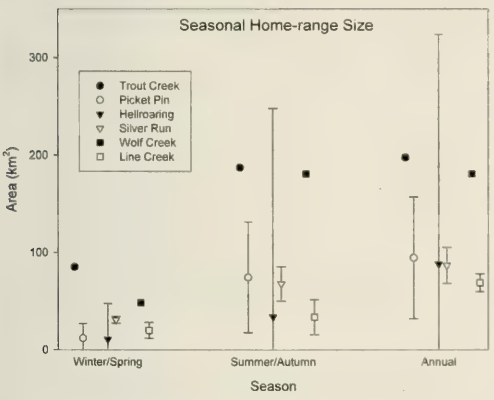

FIGURE 2. Seasonal and annual home area sizes of source populations and associated dispersing groups of Elk in south-central Montana, USA, 1988-1991. Bars indicate 95% CI.

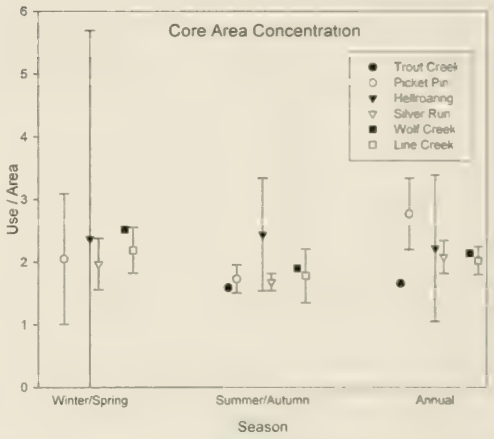

FIGURE 3. Core area concentration indices (% use of core area/% contribution of core area to home area) of source populations and associated dispersing groups of Elk in south-central Montana, USA, 1988-1991. Bars indicate 95% CI.

Elk used lower elevations in summer ($t_{123} = 3.62$, $P < 0.0001$), consistent with their tendency to move to traditional, high elevation summer range later than PP Elk. Similarly, WC Elk used lower elevations in summer ($t_{212} = 2.03$, $P = 0.05$) and autumn ($t_{157} = 2.46$, $P = 0.02$), reflecting their tendency to spend at least part of these periods off the Line Creek Plateau and away from the main LC population. Hellroaring Elk used elevations similar to SR Elk in all seasons, had non-overlapping ranges in summer and autumn, and persisted on their new ranges throughout both seasons in all years. In contrast, TC and WC Elk always abandoned the non-traditional ranges at some point during the summer.

Over time, it became apparent that dispersing groups abandoned non-traditional ranges more quickly in drier years. I examined the strength of this relationship at the conclusion of the study through a logistic regression analysis relating June and July rainfall (estimated

TABLE 3. Proportional availability and use of vegetation communities on summer-autumn range by the Silver Run Elk population and an associated population (Hellroaring) colonizing non-traditional range in disjunct areas in south-central Montana, USA, 1988-1991. *P* values (Bonferroni corrected) equal the probability that proportional use equals availability.

Vegetation community	Proportion available	Proportion used		Standardized selection ratio		*P*	
		Silver Run	Hellroaring	Silver Run	Hellroaring	Silver Run	Hellroaring
Alpine	0.70	0.48	0.48	0.08	0.07	<0.001	0.02
Lodgepole Pine	0.04	0.22	0.29	0.60	0.70	<0.001	<0.001
Sagebrush	0.08	0.14	0.12	0.21	0.16	0.27	1.00
Whitebark Pine	0.18	0.16	0.11	0.11	0.07	1.00	1.00

TABLE 4. Proportional availability and use of vegetation communities on spring-summer range by the Line Creek Elk population and an associated population (Wolf Creek) colonizing non-traditional range in disjunct areas in south-central Montana, USA, 1988-1991. *P* values (Bonferroni corrected) equal the probability that proportional use equals availability.

Vegetation community	Proportion available	Proportion used		Standardized selection ratio		*P*	
		Line Creek	Wolf Creek	Line Creek	Wolf Creek	Line Creek	Wolf Creek
Alpine	0.33	0.17	0.39	0.05	0.16	<0.001	1.00
Douglas Fir	0.08	0.14	0.08	0.15	0.13	0.11	1.00
Grass-forb	0.02	0.06	0.06	0.31	0.44	0.001	0.17
Limberpine	0.10	0.33	0.07	0.30	0.09	<0.001	1.00
Sagebrush	0.30	0.18	0.40	0.05	0.18	<0.001	0.60
Spruce	0.08	0.09	0.00	0.04	0.00	1.00	0.17
Whitebark Pine	0.09	0.04	0.00	0.10	0.00	0.21	0.13

TABLE 5. Proportional availability and use of vegetation communities on annual range by the Picket Pin Elk population and an associated population (Trout Creek) colonizing non-traditional range in disjunct areas in south-central Montana, USA, 1988-1991. *P* values (Bonferroni corrected) equal the probability that proportional use equals availability.

Vegetation community	Proportion available	Proportion used		Standardized selection ratio		*P*	
		Picket Pin	Trout Creek	Picket Pin	Trout Creek	Picket Pin	Trout Creek
Alpine	0.07	0.02	0.12	0.04	0.25	0.57	1.00
Douglas Fir	0.15	0.13	0.42	0.11	0.39	1.00	<0.001
Grass-forb	0.25	0.56	0.33	0.28	0.18	<0.001	1.00
Limberpine	0.04	0.10	0.01	0.35	0.05	0.01	1.00
Lodgepole Pine	0.26	0.05	0.09	0.02	0.05	<0.001	0.06
Sagebrush	0.05	0.02	0.03	0.06	0.08	1.00	1.00
Spruce	0.16	0.11	0.00	0.09	0.00	1.00	0.03
Whitebark Pine	0.02	0.01	0.00	0.05	0.00	1.00	1.00

TABLE 6. Volume (m^3/ha) of forbs and graminoids in core foraging areas of dispersing population groups and associated source populations in south-central Montana 1988-1991. *n* (number of sampled macroplots) = 5 except for Line Creek (*n* = 4) and Silver Run (*n* = 3). Means of plant volume in areas used by dispersing groups and areas used by source populations compared by *t*-test, same categories.

Area	Volume (m^3/ha)			
	Forbs		Graminoids	
	m^3/ha	SE	m^3/ha	SE
Trout Creek	515[a]	62	1218[a]	230
Picket Pin	228	32	307	22
Hellroaring	318[a]	11	326[a]	84
Silver Run	215	15	1002	376
Wolf Creek	69[a]	18	372[a]	65
Line Creek	415	108	210	7

[a] Different from source population. $P < 0.0001$.

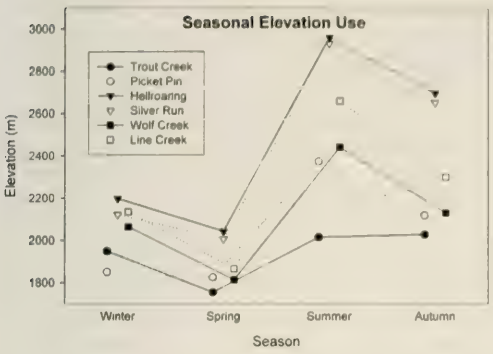

FIGURE 4. Seasonal elevational use (m) of source populations and associated dispersing groups of Elk in south-central Montana, USA, 1988-1991.

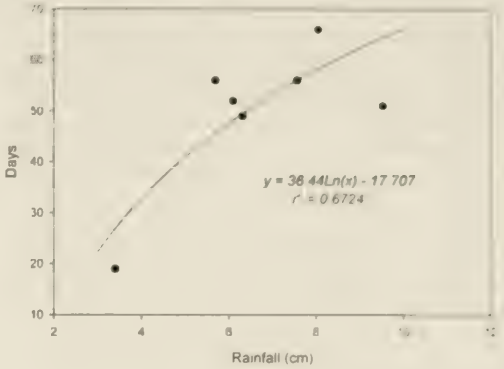

FIGURE 5. Relation between June and July rainfall (combined) and estimated number of days on non-traditional summer range in the Trout Creek and Wolf Creek dispersing groups in south-central Montana, USA, 1988-1991.

from the Red Lodge, Montana recording station for WC Elk and the Nye, Montana recording station for TC Elk, NOAA 1992) to the total estimated number of days in June, July, and August on new range. Variation in combined June and July rainfall explained two-thirds ($r^2 = 0.67$, $P < 0.0001$) of the variation in days on non-traditional summer range in the TC and WC groups (Figure 5).

Discussion

Dispersal and density of populations

Historical expansion and contraction of ranges of ungulate species has been influenced by many factors, both natural and anthropogenic (Laliberte and Ripple 2004), but range expansions at local levels are often achieved by dispersal, which in turn may be mediated by density (Andersen et al. 2004). An ecological correlate of a population's capacity to colonize new range is its ability to yield a large colonizing group (Safriel and Ritte 1983), something which can be best achieved during periods of population growth. In this area, annual aerial counts indicated that all source populations experienced population growth on traditional range in the decade prior to this study. From 1979 to 1988, the PP population increased from 44 to 190 individuals (355%), the SR population from 72 to 139 individuals (93%), and the LC population from 85 to 127 individuals (49%) (Van Dyke et al. 1998), and all populations continued to increase through 1991. These increases are small relative to fluctuations in historically large populations of Elk like the nearby Northern Yellowstone Population which has ranged from 10 000 to 20 000 individuals in recent years (Committee on Ungulate Management in Yellowstone National Park US National Research Council 2002). Nevertheless, such increases were proportionately large relative to past population size and occurred on very small annual ranges (84 – 166 km^2) (Van Dyke et al. 1998) compared to those of the Northern Yellowstone Population, whose annual range encompasses thousands of km^2 (Committee on Ungulate Management in Yellowstone National Park U.S. National Research Council 2002). Thus, it is reasonable to believe that the numerical increases observed in these herds on these restricted ranges would increase densities and competition for space and other resources, contributing to the formation of dispersing groups, although the dispersive behavior seen in these small populations might be very different from that observed in larger populations.

Size of home range and use and productivity of vegetation communities

Variability in use and selection patterns of vegetation communities in different populations is, in part, evidence of the behavioral plasticity of Elk. As these populations experienced relatively large proportional increases, the movement and fidelity of colonists to new ranges appeared similar to observed seasonal movements of White-tailed Deer (*Odocoileus virginianus*) in areas fragmented by agriculture (Nixon et al. 1991). However, whereas deer occupied traditional vegetation communities in the new areas to which they dispersed, Elk in these dispersing groups demonstrated their plasticity in habitat selection by changing their patterns of use of vegetation communities as they moved to new ranges.

It is not only the proportion of a vegetation community in the landscape that determines its use by Elk, but also its juxtaposition and interspersion with other such communities (Porter and Church 1987), a dimension of availability that was beyond the scope of this study to measure. Thus, use of vegetation communities by specific populations would be a poor guide for landscape scale habitat management. In these populations Elk adjusted use of vegetation communities according to local and seasonal availabilities.

Use of marginal habitats is associated with increased rates of range expansion in some ungulate species (Andersen et al. 2004). The larger home ranges of TC and WC groups using non-traditional lower elevation ranges in summer might indicate the same trend. Further, larger home ranges in these groups also suggested that forage on non-traditional ranges might have been more dispersed. However, comparisons of forage volume in core foraging areas of group and source populations did not support the premise that productivity was lower in ranges of dispersing groups. On the TC range, forage volume was higher in both graminoids and forbs. However, foraging areas for TC Elk were concentrated in riparian areas and probably could not support higher densities or more extended use by Elk in most years. Nutritional quality of vegetation is often better at higher elevations (Johnston et al. 1968; Boyce 1989), a trend confirmed on these ranges in measurements of protein and other nutrients in low vs. high-elevation plants (Van Dyke et al. 1991; Van Dyke et al. 1994). However, McCorquodale (1991) found that, in sagebrush habitats used by Elk in central Washington similar to those used by the WC group, low intercommunity variability in forage production, lack of a nonforage overstory, and the relative abundance of foraging areas all mitigated against lower primary production.

The low-elevation, mostly treeless habitat of the WC group appeared to provide the greatest potential for heat stress of Elk during summer months because of its absence of thermal cover. However, Peek et al. (1982) have argued that thermal cover is not a requirement for Elk. Elk historically occurred on the Great Plains and in other areas that lacked thermal cover. Loss of Elk in these areas was due to human influence, not lack of adaptability to the habitat (Laliberte and Ripple 2004). In recent years Elk have recolonized areas in treeless, sagebrush-steppe habitats in central Washington (Rickard et al. 1977; McCorquodale et al. 1986; McCorquodale 1991) similar to those used by the WC Elk.

Both source populations and dispersing groups demonstrated fidelity to their selected home ranges from year to year. Such fidelity suggested that dispersing groups had already established some degree of tradition in their use of new ranges and were not dispersing randomly. However, early abandonment of non-traditional range at low elevations under drier conditions suggested that such new ranges might have been sub-optimal environments for Elk compared to traditional range. Dispersing groups responded to periods of environmental stress by rejoining source populations on traditional areas. By doing so, individuals in dispersing groups might have benefited from the source population's collective knowledge of available resources on traditional range and its successful, long-term strategies of range use (Edge et al. 1985).

Management Implications

Elk in dispersing groups demonstrated an ability to locate and adapt to non-traditional range through various combinations of altered habitat use, changes in patterns of seasonal elevational migration and adjustments in home range size and use. Given this repertoire of adaptive strategies, managers should assume that areas adjacent to existing Elk populations but presently without Elk could be colonized, and could be of importance to future growth of such populations and expansion of their range. For example, in restorations of Elk in Kentucky (USA), translocated Elk demonstrated fidelity to a variety of habitat types, including some not previously encountered on their original ranges (Larkin et al. 2004). Such considerations are of importance to managers as efforts to restore Elk populations in several U. S. states (Didier and Porter 1999; McClafferty and Parkhurst 2001; Larkin et al. 2004) are being considered or have commenced.

As noted previously, dispersing groups from these smaller populations might not exhibit the same patterns or behaviors associated with dispersal as has been observed in historically large herds. Thus, it would be advisable to consider and evaluate dispersive behavior associated with populations of different sizes before making broad generalizations about patterns of dispersive behavior that could apply to populations of all sizes. However, even with this caveat in hand, it will be true that expanding ranges and growing populations of Elk, regardless of size, might create added opportunity to view and hunt Elk, but such expansion could contribute to increasing conflict between Elk and other land uses such as agriculture and must be examined in a regional context. Where colonization of new range by Elk enhances the persistence of marginal populations and provides desired recreational opportunities for hunting and viewing Elk, managers should identify, provide access to, and, if possible, acquire adjacent range to which individuals might disperse, especially within the broader context of regional strategies that follow the principle of retaining large contiguous or connected areas that contain critical habitats (Dale et al. 2000). In these cases, dispersing groups should be protected from disturbance until they have established fidelity to new ranges (Larkin et al. 2004). Where dispersion to adjacent, but non-traditional ranges and habitats is likely to create or exacerbate land use conflicts between Elk and humans, managers should consider lowering densities of Elk on traditional range to reduce the likelihood of such dispersal.

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The Rumsfeld Paradigm: Knowns and Unknowns in Characterizing Habitats Used by the Endangered Sharp-tailed Snake, *Contia tenuis*, in Southwestern British Columbia

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The Sharp-tailed Snake, *Contia tenuis*, has a small and highly fragmented range in British Columbia, where it is considered endangered. Known sites are few in number and generally small in spatial extent; numbers of snakes apparently are correspondingly low. Furthermore, most known sites for the species are on private lands in areas that are fairly heavily developed or being developed. Thus, the species is under serious threat of habitat alteration or loss. Although land stewardship has been a valuable conservation tool in this case, we also need to identify the key habitat requirements of Sharp-tailed Snakes to identify potential new sites, modify former or potential ones, or even create new ones. In this study, we compared sites known to harbour Sharp-tailed Snakes with those that seemed subjectively similar and therefore potentially suitable. We also compared these known and potential sites with randomly chosen nearby locations. Variability of most measured features was high, both within and among site/location categories. Nonetheless, we found significant differences between known and potential sites and between those locations and random ones. Overall, locations known to be used by snakes had a more southerly aspect, more rock cover, shallower soil and litter, and less shrub cover than other sites. This study was constrained by the small number of known sites for Sharp-tailed Snakes in southwestern British Columbia, making our conclusions suggestive rather than definitive. Future work should incorporate additional variables. It also might be useful to undertake comparative habitat studies elsewhere in the range of the Sharp-tailed Snake where it is more common.

Key Words: Sharp-tailed Snake, *Contia tenuis*, habitat, British Columbia.

On 12 February 2002, U.S. Secretary of Defense Donald Rumsfeld made the following widely cited observation:

"As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say, we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know. And if one looks throughout the history of our country and other free countries, it is the latter category that tend to be the difficult ones."

Although Rumsfeld was not discussing science, his circumlocutional comments nonetheless may well be apt in science (Shermer 2005). In conservation biology, the unknowns, whether known or unknown, usually exceed the known knowns and we often have to make educated guesses in, for example, trying to determine where there might be additional suitable habitats for a threatened or endangered species.

To manage and conserve any species, it is crucial to understand its habitat requirements. The fitness of any species should be greatest in a habitat for which it is best suited and that it presumably prefers (Garshelis 2000). Determining critical habitats is an important component of the background knowledge that allows researchers and managers to develop strategies to either recover or maintain an endangered or threatened species and to choose areas in which to explore such strategies.

The Sharp-tailed Snake (*Contia tenius*) is a small secretive snake, from 20 to 45 cm in total length when adult (Leonard and Ovaska 1998), that ranges from southern California to southern British Columbia (Cook 1960). Although the southern part of its range, to northern Oregon, is more-or-less continuous, the distribution of this species is highly fragmented in Washington and British Columbia (Leonard and Ovaska 1998). In British Columbia, Sharp-tailed Snakes are known only from a small number of scattered locations on southern Vancouver Island and some of the adjacent Gulf Islands. A previous report from Chase in the interior of British Columbia is of doubtful origin (Matsuda et al. 2006). Because of the low numbers of snakes found in Canada and few known sites, the snake was considered an endangered species by COSEWIC in 1999 (COSEWIC 2002*). Although formal study of Sharp-tailed Snakes has been limited, recent studies done in British Columbia and adjacent Washington cover aspects of their ecology such as defensive behaviour (Ovaska and Engelstoft 1999; Leonard and Stebbins 1999), aggregative behaviour (Leonard et al. 1996),

movements (Engelstoft et al. 1999), habitat (Leonard and Leonard 1998), and cover use (Engelstoft and Ovaska 2000).

Most of the areas where the Sharp-tailed Snake is found in British Columbia have fairly dense human populations and highly disturbed habitat. Consequently, many of the sites at which snakes are found are on private land. Although the Sharp-tailed Snake seems somewhat tolerant of anthropogenic habitat disturbance, habitat loss is still considered the primary threat to its persistence in Canada. Therefore, management and stewardship by landowners are important factors in conservation programs for this species.

The aim of this study was to determine the key characteristics that define habitats used by the Sharp-tailed Snake, in order to guide future habitat management. We did this by comparing sites known to be used by Sharp-tailed Snakes with sites that were subjectively similar but not known to be used (potential sites), and with locations chosen at random with respect to both known and potential site types. The first comparison objectively tested whether potential sites actually are similar to those sites known to be used by these snakes and the second tested whether Sharp-tailed Snakes use a subset of those habitats that are available. Initial observations suggested that south-facing rocky slopes and forest clearings appeared to provide the most suitable habitat for this species (see also Leonard and Leonard 1998), but no quantitative assessment of habitat characteristics has previously been done. Thus, we measured a wide range of possibly influential habitat variables at each sample location and compared them statistically among locations.

Although our comparisons among sites and locations were objective, selection of potential sites obviously was biased by our general knowledge of snake ecology and our previous experience with Sharp-tailed Snakes. This mainly reflected an aim of the recovery program for this species to find as many occupied sites as possible.

Study Area

In the past few years, federal lands in the Capital Regional District (including Gulf Islands National Park, Department of National Defence lands, and Coast Guard properties) have been assessed and rated for suitability as habitat for the Sharp-tailed Snake (Engelstoft and Ovaska 1998*). These sites are in various locations on North and South Pender Islands, Saltspring Island and southern Vancouver Island. In addition, artificial cover objects (ACOs) have been installed at all sites at which Sharp-tailed Snakes are known to occur, including private lands, and at sites rated as having high potential as habitat for these snakes. ACOs provide easily sampled, attractive cover and, combined with naturally occurring cover objects, are an effective means of determining presence of snakes (Engelstoft and Ovaska 2000). Sharp-tailed Snakes are secretive and rarely seen in the open, and ACOs provide the main means by which they are discovered in the field. Potential sites in this study were identified by CE based on his extensive field experience with Sharp-tailed Snakes.

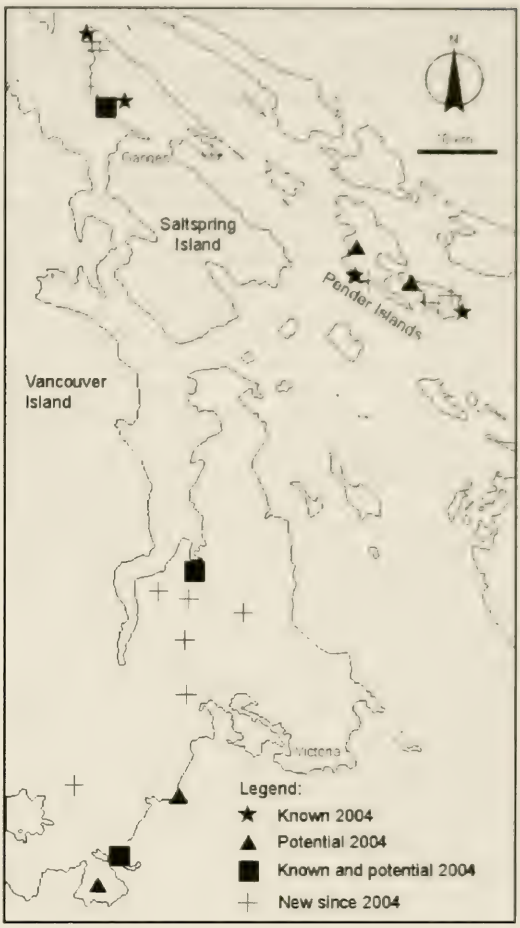

FIGURE 1. Map of study area with sites known to be occupied by Sharp-tailed Snakes up to 2004 and since, and potential sites identified in 2004. Squares labeled "known and potential 2004" indicate known and potential sites that are too close together to represent separately on this map. For reference, latitude and longitude for Victoria are 48°25'N and 123°19'W, respectively, and for Ganges 48°51'N and 123°31'W, respectively. Modified from a map obtained from the Natural Areas Atlas on the Capital Regional District (2008*) website.

The sites where ACOs have been placed can be classified into two general types. Unrestricted sites are those with relatively large extents of contiguous habitat under the same ownership surrounding the location of the ACO. These areas typically have experienced relatively little disturbance in the last century (e.g., Department of National Defence lands or Canada Parks lands). Restricted sites are those on relatively

small, privately owned properties surrounded by private lands in relatively developed areas. These locations have generally experienced a greater degree of habitat modification (buildings, roads, gardens, etc.).

Methods

Fieldwork for this study was undertaken in summer and autumn of 2004. Our general sampling scheme was straightforward. The 31 sites were divided into two site types, those known to harbour Sharp-tailed Snakes (known knowns) and those that appeared to have the potential to harbour them (known unknowns). Hereafter, we call these known and potential sites, respectively (Figure 1). At each of these sites, in addition to the known or potential *assigned* location, we also chose a corresponding *random* location (unknown unknowns) for sampling. Random locations were 50 m from an assigned location, but in a randomly chosen direction. Because 50 m was well within the known movement capabilities of *Contia* (Engelstoft et al. 1999), yet far enough away for the environment to vary significantly, this distance provided a test of non-random use of the local habitat. However, because most known sites are restricted, we were able to obtain a random location for only seven of the 16 known sites (compared to 14/15 for potential sites). Our sampling protocol was thus dictated to a large degree by access to private property, and by the amount of contiguous habitat under the same ownership surrounding the site. The total number of assigned and random locations at all sites combined was 52. At each of these locations, we took samples along three randomly chosen 10-m-long transects.

The first transect at each assigned location was placed in a random direction from a randomly chosen ACO, so that the 0-m mark was at the centre of the ACO. The other two transects were placed at two different randomly chosen locations (and in random directions) within a 25-m radius of the initial ACO. We measured canopy cover, aspect, and slope of location at the 0-m mark of the first transect; that is, these variables were measured once per location. All other variables were measured along each of the three transects (i.e., three replicates for each location). This same protocol was repeated for random locations, with a point on the ground standing in for an ACO. We ensured that transects around an assigned location and its associated random location did not overlap or abut each other.

We measured the following variables at each of the 52 locations:

1. **Percentage canopy cover** — Canopy cover was measured once for each location at the starting point of the first transect, directly overhead, and then at a 45° angle in each of the cardinal directions (south, north, east and west – surrounding canopy cover). The tree species making up the canopy cover also were recorded.
2. **Aspect** — The aspect of each location was measured in degrees using a compass at the starting point of the first transect. A measurement of 180° indicates a southerly aspect.
3. **Slope** — The general slope of the location was recorded in degrees as well as the slope for each separate transect. Both were measured using a compass equipped with a clinometer.
4. **Substrate** — At the 1-m mark along each transect, we determined the depth of both soil and litter layer by measuring the distance a thick wire penetrated into the ground. The composition of the litter (needles, leaves, etc.) also was recorded.
5. **Rock coverage** — Rock coverage was determined at each transect by measuring the total distance intercepted by rocks along the length of the transect. The rocks were rated by size as follows: loose gravel (pebbles <7.5 cm), cobbles (7.5-19.9 cm), rocks (20-50 cm), boulders (>50 cm), and bedrock.
6. **Coarse woody debris** — This was determined by measuring the total distance intercepted by coarse woody debris along the transect. Each piece of coarse woody debris was identified to species (if possible), and assigned a decay class (1-5) as per Table 5.13 in Meidinger (1998*).
7. **Vegetation** — Shrub cover and ground cover were determined by measuring the total distance intercepted by vegetation along the transect. For logistical reasons, coverage by each of lichens, bryophytes, grass and forbs was expressed as the total distance intercepted by these plants between the 2-m and 4-m marks of each transect.

Statistical Analyses

We used SAS 8.0 to analyze the data, except for aspect, which we also analyzed using ORIANA software. We compared locations and site types using both univariate and multivariate statistics. Although one level of the factor "location" was a randomly selected partner to a known or potential assigned location for Sharp-tailed Snakes, all factors (site, site type, location) were treated as fixed factors because all sites initially were chosen deliberately as particular site types and locations. In cases of non-orthogonal data, we used Type III sums of squares for F-tests. As this was essentially an exploratory study, we used a liberal criterion for tests of significance, highlighting all results for which $P < 0.10$.

Most variables showed no clear pattern of heterogeneity among categories of sites, so we combined them in various ways, which also reduced the number of variables to manageable levels, as follows: total shrub coverage (all shrubs – e.g., broom, Oregon grape, salal); tall, non-shrub coverage (ferns and asters); thick ground cover (e.g., ivy, periwinkle, trailing blackberry); light ground cover (lichens, bryophytes, grasses, forbs); rock cover (sum of all rock-size classes); coarse woody debris (sum of all CWD decay classes); and surrounding canopy cover (average of directional values around sample location). All other variables (e.g. overhead canopy cover, soil depth, slope) were left unaltered.

Because assigned and random locations were paired at unrestricted sites, we compared them via a 2-way factorial analysis of variance (ANOVA), with the three transects treated as replicates within each combination

of site and location. We did this analysis separately for known and potential site types, as they were in different places. In each case, we had to drop restricted sites from the analysis because they lacked a random location. In all cases in which the interaction between factors was non-significant, we dropped it from the analysis to test main factors only. In cases in which the interaction was significant, compromising interpretation of main effects, we then did a comparison of locations for each site separately.

To compare known and potential site types, we used a nested ANOVA (sites nested within site type), analyzing assigned and random locations separately, with transects serving as replicates within locations. F-tests were adjusted to those appropriate for nested ANOVA (Sokal and Rohlf 1981).

Because aspect is an angular variable, with the lowest possible value (0°) identical to the highest possible (360°), we treated it differently from the other variables. We categorized aspect at each location as one of four quadrants representing the four cardinal directions and then compared frequency of directions among site type/location categories (known/assigned, known/random, potential/assigned, potential/random) by contingency-table analysis. We also used circular (angular) statistics, as described by Zar (1984), to compare mean aspect between pairs of site type/location categories.

In addition to aspect, a few other variables (e.g. canopy cover) were recorded only once for each location, rather than separately for each transect. We therefore reduced the data set to average values for each location and then analyzed those new variables using two-way ANOVA (site × type × location, sites serving as replicates within each combination of factor levels). Again, we dropped the interaction term when it was non-significant, but did a separate comparison of locations at each site type when the interaction was significant. We also tested for correlations among these variables across all sites/locations.

Studies of habitat relationships are necessarily multivariate (Reinert 1993) and typically involve methods such as Principal Components Analysis (PCA) and Discriminant Function Analysis (DFA). In comparing categories of habitats, such as we have in this study, two approaches are possible (Quinn and Keough 2002). One is the multivariate analysis of variance (MANOVA) approach embodied by Discriminant Function Analysis (DFA). A second is to do a Principal Components Analysis (PCA) of all groups combined and then compare the derived components among groups using univariate ANOVA. Although the two approaches do not produce identical results, they generally result in broadly similar patterns of group differences (Quinn and Keough 2002). Advantages of the PCA approach include ease of analysis of multiple derived components and straightforward *post hoc* comparisons of particular groups (Quinn and Keough 2002), so we used it here.

To avoid pseudo-replication, especially for variables for which only one measurement was made per location (see above), we used the reduced data set (i.e., means of the three transects treated as data) for multivariate analysis. Using the same variables as in the ANOVAs above, we subjected the data to PCA, examined each of the first three principal components for influence of the original variables, and then treated each of the principal components as variables in separate two-way ANOVAs (as above). We also used the first principal component (PC 1) as the independent variable in a logistic regression comparing sites/locations known to be used by *Contia* vs. all other sites.

Results

Two-way ANOVAs using individual transect data as values yielded few differences attributable to location, although sites differed significantly for several variables. In comparisons of assigned vs. random locations for known site types, we found an effect only of rock cover, which was higher at assigned than at random locations ($F_{1,34} = 3.42$, $P = 0.07$). In cases of variables for which there was a significant interaction between site and location (extent of litter, slope of transect, coarse woody debris), differences between locations were significant at some sites, but not in any consistent direction.

For potential site types, assigned and random locations differed only in thick ground cover ($F_{1,69} = 38.8$, $P = 0.053$), which was higher in assigned locations. Sites again differed significantly for several variables and the interaction between site and location was significant for four variables (extent of litter, rock cover, light ground cover, shrub cover). Patterns from interactions again generally were indistinct, but for the three sites that differed significantly in rock cover, the value was higher at assigned than random locations; for three sites differing significantly in shrub cover, the value was lower at assigned locations.

Nested ANOVAs comparing assigned locations between known and potential site types showed only that known site types had lower soil depth ($F_{1,29} = 3.20$, $P = 0.08$) and less coarse woody debris ($F_{1,29} = 7.45$, $P = 0.01$) than potential site types. Again, there were significant differences among sites for some variables. Similar comparison of random locations between known and potential site types revealed only that rock cover was higher at known site types ($F_{1,19} = 3.15$, $P = 0.09$), with sites again varying significantly for some variables.

Two-way ANOVAs, using mean values (per 3 transects) as data (and all site type × location combinations, $n = 52$), revealed more differences (Table 1). Overall (i.e., assigned and random locations considered together), known site types had shallower soil ($F_{1,49} = 2.92$, $P = 0.09$), shallower litter ($F_{1,49} = 2.95$, $P = 0.09$), and higher rock cover ($F_{1,49} = 4.67$, $P = 0.04$) than

TABLE 1. Statistical summary of main habitat variables by site type (known vs. potential) and location (assigned vs. random). Only variables that were significantly different in at least one analysis (see text) are shown. Individual data are means for 3 transects at each site type/location combination; shown in the table are mean (top row) and ± standard deviation, minimum value – maximum value (bottom row) of these transect means.

Site type	Known		Potential	
Location	Assigned (n = 16)	Random (n = 7)	Assigned (n = 15)	Random (n = 14)
Rock Cover (m)	2.7	2.1	1.6	0.9
	2.45, 0 – 7.46	2.24, 0.02 – 6.03	1.78, 0.02 – 6.40	1.04, 0.01 – 3.11
Coarse Woody Debris (m)	0.1	0.6	0.4	0.5
	0.18, 0 – 0.71	1.37, 0 – 3.70	0.43, 0 – 1.71	0.72, 0 – 2.07
Thick Ground Cover (m)	0.6	0	0.3	0.03
	0.96, 0 – 3.50	0, 0 – 0	0.56, 0 – 1.61	0.05, 0 – 0.14
Shrub Cover (m)	1.8	2.3	1.8	3.5
	1.83. 0 – 5.29	1.42, 0.41 – 4.00	1.85, 0 – 6.95	3.04, 0 – 9.95
Soil Depth (cm)	6.6	8.4	9.0	9.4
	2.44, 3.5 – 10.9	3.58, 3.6 – 13.2	4.85, 4.3 – 22.2	4.30, 2.7 – 17.0
Litter Depth (cm)	2.1	2.2	2.7	3.3
	1.26, 0 – 4.3	1.46, 1.0 – 5.3	1.14, 0.7 – 4.2	2.23, 0.7 – 8.7
Overhead Canopy (%)	28.8	17.1	7.3	28.2
	21.17, 0 – 60.0	22.15, 0 – 50.0	14.25, 0 – 50.0	21.6, 0 – 50.0
Surrounding Canopy (%)	25.4	21.1	19.1	35.1
	12.39, 2.5 – 52.5	16.51, 0 – 42.5	14.74, 0 – 46.3	18.66, 0 – 52.5
Transect Slope (°)	13.0	15.4	11.2	7.7
	7.76, 0 – 28.33	15.39, 0 – 45.33	9.56, 0 – 27.67	7.24, 0.67 – 27.33

potential site types, on average. Assigned locations had more thick ground cover ($F_{1,49} = 4.15$, $P = 0.047$), less shrub cover ($F_{1,49} = 3.59$, $P = 0.06$), less overhead canopy cover (potential site types only, $F_{1,27} = 9.55$, $P = 0.005$) , less surrounding canopy cover (potential site types only, $F_{1,27} = 6.62$, $P = 0.02$), and steeper transect slopes (potential site types only, $F_{1,27} = 5.90$, $P = 0.02$) than random locations, on average.

As expected, many of the variables above were significantly correlated over all site types/locations (n = 52 in all cases). These included mean soil depth vs. mean litter depth (r = 0.40, $P = 0.004$), mean rock cover vs. mean litter depth (r = -0.29, $P = 0.04$), mean soil depth vs. mean rock cover (r = -0.38, $P = 0.005$) and overhead canopy cover vs. surrounding canopy cover (r = 0.58, $P < 0.0001$).

Direction (aspect) differed significantly among site type/location categories (Fisher's exact test, $P = 0.004$). Thirteen known/assigned locations (81%) faced south and the rest (3) all faced west, whereas only six (40%) of potential/assigned locations faced south and another six faced east. Potential/random locations were particularly deviant from known/assigned, with eight (57%) facing either north or east. These results were consistent with those from analysis via circular statistics (mean vectors: known assigned – 203.99°; known random – 215.15°; potential assigned – 155.73°; potential random – 125.86°). Significant differences between site type/location categories were as follows: known assigned vs. potential assigned – $F_{1,29} = 4.27$, $P = 0.05$; known assigned vs. potential random – $F_{1,28} = 7.21$, $P = 0.01$; known random vs. potential assigned – $F_{1,20} = 3.02$, $P = 0.1$; known random vs. potential random – $F_{1,19} = 3.55$, $P = 0.07$, although this last result may not be reliable because of a uniform distribution of points.

We ran PCA using various combinations of variables, dropping those that had low weights on PC 1. Results were broadly similar in all cases, but they were most clearly defined when we used mean rock cover, mean soil depth, mean surrounding canopy cover, and mean shrub cover as variables in the analysis. In that case, PC 1 accounted for 44% of the total variance and PC 2 and PC 3 23% and 20%, respectively. This high cumulative percentage variance for the first three principal components suggests that they summarized the data efficiently (McGarigal et al. 2000). PC 1 was positively weighted by soil depth, surrounding canopy cover, and shrub cover, but negatively weighted by rock cover (Table 2).

Two-way ANOVAs on the PCs showed that PC 1 differed overall between both site types ($F_{1,49} = 4.19$, $P = 0.046$) and locations ($F_{1,49} = 4.84$, $P = 0.03$). Known site types had lower average values of PC 1 than potential site types and assigned locations had lower values than random, consistent with the two-way ANOVAs performed above on the individual variables and with the signs of coefficients in PC 1. Random locations had higher values of PC 2 than assigned locations, but only for potential site types ($F_{1,27} = 3.86$, $P = 0.06$). Neither site types nor locations differed with respect to PC 3.

Despite statistically interesting differences in PC 1 between site types and locations, differences overall

TABLE 2. Summary of weights (coefficients) of four variables on first three principal components in analysis of habitat variables potentially influencing occurrence of Sharp-tailed Snakes. PC 1 accounts for 44% of variance and PC 2 and PC 3 23% and 20%, respectively.

Variable	PC 1 Coefficients	PC 2 Coefficients	PC 3 Coefficients
Soil Depth	0.497	-0.591	0.346
Surrounding Canopy Cover	0.440	0.549	0.670
Shrub Cover	0.489	0.490	-0.562
Rock Cover	-0.566	0.331	0.339

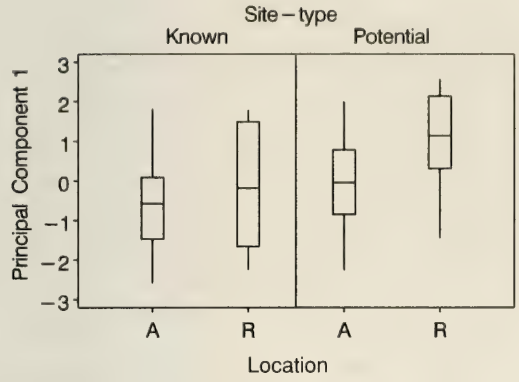

FIGURE 2. Box-and-whisker plots of values of principal component 1 by site type (known vs. potential) and location (actual, A, vs. random, R). Horizontal line in each box is median. Upper and lower boundaries of box (hinges) indicate quartiles (25th and 75th percentiles). Whiskers from box reach to the most extreme value that does not exceed 1.5 times the distance between the quartiles; $n = 52$.

among the four site type/location combinations were not large (Figure 2). In fact, differences among these categories were graded rather than discrete. We therefore divided site type/location combinations into two categories, those known to be occupied by Sharp-tailed Snakes and those not. The resulting binomial variable was then regressed (logistic regression) against PC 1. The logistic model was a satisfactory fit to the data (Homer and Lemeshow test, $\chi^2_8 = 4.46$, $P = 0.81$) and the relationship was significantly negative (Wald's $\chi^2_1 = 4.25$, $P = 0.04$; Figure 3). We also compared PC 1 of known/assigned locations successively, via logistic regression, to known/random, potential/ assigned and potential/random locations. The trend also was negative in each case, but significant (and strongly so) only in the last one. Thus, sites known to be occupied by Sharp-tailed Snakes differed from those not known to be occupied.

Discussion

The study of how and why animals occur in particular habitats has a long history in ecology and has been the subject of numerous reviews and syntheses (e.g.

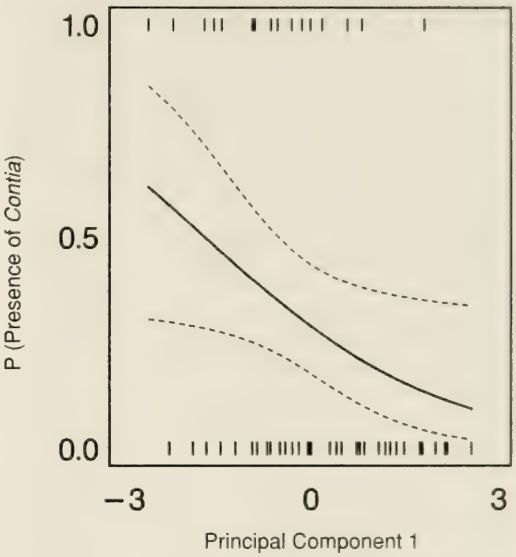

FIGURE 3. Logistic regression of presence(1)/absence(0) of Sharp-tailed Snakes vs. principal component 1 for all site type/location combinations. Absence implies "not recorded" rather than confirmed absence. Vertical lines are data points, solid line is predicted regression, and dashed lines are upper and lower 95% confidence limits on regression; n = 52.

Morse 1980; Gray and Craig 1991; Reinert 1993; Garshelis 2000). Habitat use by a species is a function not only of habitat selection based on resource requirements and physical factors such as temperature, but of other factors such as population density and the presence of competitors and predators (Huston 2002; Morris 2003). Thus, the habitats used by animals may not be those that are optimal for them in terms of fitness. In fact, it is even possible that some occupied habitats have negative implications for fitness (Van Horne 1983), for example if those habitats are sinks in a source-sink system (Pulliam 1988). Conversely, optimal habitats that could be used might not be occupied simply because the species' ability to disperse there is limited (Huston 2002). In short, the analysis and interpretation of habitat-use studies is fraught with difficulties (Garshelis 2000). In that light, this study

is but a small first step towards understanding the habitat relationships of the Sharp-tailed Snake. It is further limited by its reliance on presence/absence (really presence/not recorded) data rather than data on abundance, or better, demographic performance (Pulliam 1988; Garshelis 2000). In terms of Garshelis' (2000) classification of methods, our approach is a variant of the site-attribute design, but with the added inclusion of predetermined potential sites for the species' occurrence.

Animals typically do not use their environments at random, but non-randomly, selecting some sites over others because of particular habitat and micro-habitat features. Thus, the mere demonstration that places used by a particular species are different from those not used is unremarkable by itself. For the conservationist or manager, however, determining which habitat characteristics are important is fundamental to preservation, restoration, or even creation of habitats.

What are the key features that describe suitable habitats for the Sharp-tailed Snake? The data collected in this study were highly variable and can only hint at differences between site types and locations that appear to be important. More detailed, longer-term work with larger samples would allow us to reach stronger conclusions, but this study was limited by the small number of sites at which the Sharp-tailed Snake is known to occur in southwestern British Columbia. It also was limited by the subjectivity with which potential sites were identified. For example, south-facing slopes are often favoured by snakes and this is reflected in the distribution of known and potential sites in this study. However, a Sharp-tailed Snake recently was found on a north-facing slope on Pender Island (D. Spalding, personal communication), suggesting that the species may occur in a wider range of conditions than previously thought. Currently, a more randomized approach to sampling sites for Sharp-tailed Snakes is under way to reduce this kind of bias, but we still have some way to go before we can convincingly move known and unknown unknowns to the fully known side of the ledger.

Aside from the necessary constraints of small numbers of known sites for Sharp-tailed Snakes, this study also might have been limited by failure to measure key environmental variables. For example, as is the case for other ectotherms, the ecology of Sharp-tailed Snakes is no doubt strongly influenced by temperature, which will affect the kinds of habitats and microhabitats they use at different times (Huey 1991; Reinert 1993; Blouin-Demers and Weatherhead 2001). Similarly, given the potential for desiccation in this small species, as well as a requirement for incubation sites for eggs, moisture also is likely to be an important physical factor. Therefore, cracks and openings for underground access and suitable sites for egg-laying or hibernation are potentially critical habitat features for these snakes. However, measuring subterranean access would be very difficult and we know nothing about the kinds of sites favoured by Sharp-tailed Snakes for egg deposition or for spending the winter. To deal adequately with temperature and moisture, we would need to measure them across all seasons and in multiple microhabitats per location simultaneously.

Despite these deficiencies, we found fairly clear indications that sites used by Sharp-tailed Snakes tend to be south-facing and to have relatively shallow soil and litter, relatively high rock cover, and relatively low shrub cover. Differences from randomly chosen sites emphasize this species' non-random use of habitats, but differences between locations actually used by snakes and those deemed to be potential habitat underline the subjectivity of visual habitat assessment. That said, this subjective approach based on field experience has proven effective. Although none of the potential sites used in this study have since yielded evidence of Sharp-tailed Snakes, two of the known sites were initially identified by CE as potential sites and another site designated as potential by CE after this study was completed has since turned out to be occupied by Sharp-tailed Snakes. Even so, quantitative measures for objective assessment of potential sites also would be valuable. Future work could focus on variables found to be important in this study and on others that we were unable to measure, such as those mentioned above as well as shrub height, tree density, soil composition, drainage, and type of bedrock.

Given the rarity of the Sharp-tailed Snake in British Columbia and the obvious difficulties in studying rare species in general, perhaps an alternative (or supplementary) approach would be to undertake comparative studies of this species in more southerly parts of its range where it is more widespread and more abundant. Extrapolating from a species' ecology in one part of its range to another distant one requires caution as there may be significant adaptive differences in different areas. For example, Sharp-tailed Snakes in California occupy a wide diversity of habitats (D. Wake, personal communication), most of which do not occur in British Columbia. Nonetheless, this approach might reveal fundamental species' characteristics that can be used to delineate more clearly the critical habitats required for conservation of the Sharp-tailed Snake in British Columbia.

Acknowledgments

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Do Repugnant Scents Increase Survival of Ground Nests? A Test with Artificial and Natural Duck Nests

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Ground-nesting birds typically experience high predation rates on their nests, often by mammalian predators. As such, researchers and wildlife managers have employed numerous techniques to mitigate nest predation. We investigated the use of scents as repellents to deter predators from both artificial and natural ground nests. Survival rates of artificial nests did not differ among six groups of substances (Wald $\chi^2_{df=5} = 4.53$, $P < 0.48$); however the chronology of predation among groups differed. A commercial Coyote urine based deterrent (DEER-D-TER™), human hair, and Worcestershire sauce were depredated faster than the control ($F_{4,5} = 40.3$, $P < 0.001$). Nest survival of natural nests differed among those groups tested (Wald $\chi^2_{df=2} = 11.8$, $P < 0.005$); the eight mothball treatment decreased survival (Wald $\chi^2_{df=1} = 11.5$, $P < 0.005$), which indicated that novel smells may attract predators or result in duck nest abandonment when coupled with natural duck scent. Chronologies of predation events among treatment groups were not different for natural nests ($F_{2,3} = 1.9$, $P = 0.22$). These findings indicate an interaction between novel scents and predator olfactory cues.

Key Words: Coyote, *Canis latrans*, urine, human hair, mothballs, napthaldehyde, nest predation, olfactory cues, waterfowl, Manitoba.

In the prairies of North America, predation on nests of ground-nesting ducks is considered the most important factor limiting waterfowl populations (Chafloun et al. 2002). As such, wildlife managers have developed and employed various techniques in an attempt to mitigate nest predation with varying degrees of success. Typically, a predation event by a mammalian predator such as the Striped Skunk (*Mephitis mephitis*), Red Fox (*Vulpes vulpes*), or Raccoon (*Procyon lotor*) is opportunistic (Larivière and Messier 1997). These predators are nocturnal and locate nests using audition (when the hen flushes) and olfaction (Larivière and Messier 1997). Although substances that may attract predators to nests have been investigated (Whelan et al. 1994; Clark and Wobeser 1997), scents that may repel predators from nests have yet to be tested.

Chemical compounds have been used successfully to repel animals, including mammals. Some animals have been effectively repelled by means of conditioned taste aversion (e.g., Hoover and Conover 1998) and through the use of noxious scents such as toxic compounds or odor from predatory animals (Sullivan et al. 1985; Rosell 2001).

We investigated the effectiveness of various scents to increase survival of duck nests in the Canadian prairies. Specifically, we tested whether applying DEER-D-TER™ (a commercial product containing Coyote (*Canis latrans*) urine), human hair, Worcestershire sauce, and mothball treatments could increase survival of eggs in artificial nests and the capability of DEER-D-TER and mothball treatments to increase the survival of eggs in natural duck nests. We also tested for differences in speed of predation events to determine whether specific scents may temporarily deter predators from a nest. Finally, we compared survival of eggs in artificial and natural nests.

Study Area

This study was conducted southeast of Minnedosa, Manitoba (50°14'54"N, 99°50'30"W), in an area supporting numerous small (<3 ha) seasonal to permanent wetlands (ca. 14% of study site) and characterized by intensive cultivation (63%) of small grains (wheat, barley, and oats) and oil crops (canola and flax). Intermixed among agricultural fields are small aspen bluffs composed of poplar species (largely Quaking Aspen (*Populus tremuloides*) and Bur Oak (*Quercus macrocarpa*). The predator community is diverse and includes Raccoons, Striped Skunks, Coyotes (*Canis latrans*), Red Foxes, American Badgers (*Taxidea taxus*), and American Mink (*Neovison vison*). Predation of bird nests in the area is largely attributed to mammals (Pasitschniak-Arts and Messier 1995) but avian predation also occurs, primarily by birds such as the Common Raven (*Corvus corax*), American Crow (*Corvus brachyrhynchos*), and Black-billed Magpie (*Pica pica*).

Methods

The effectiveness of five groups of substances was compared to a control using artificial nests. The repellent substances were chosen based on unsubstantiated reports of their efficacy against mammals (human hair

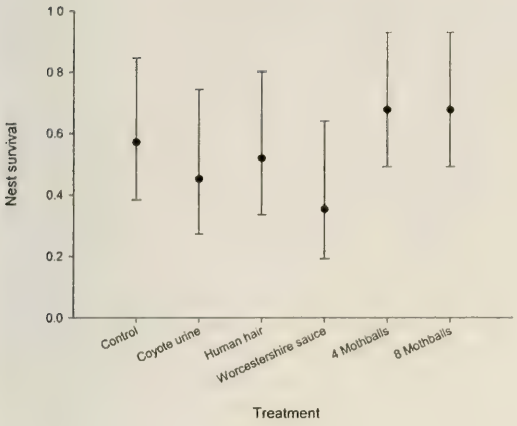

FIGURE 1. Daily nest survival (all eggs remaining in nest) of artificial duck nests treated with scents in Manitoba, 2002.

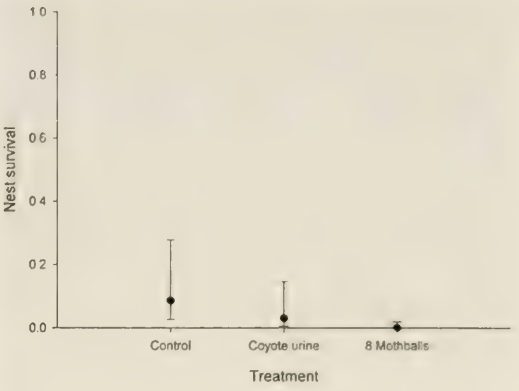

FIGURE 3. Daily nest survival (all eggs remaining in nest) of natural duck nests treated with scents in Manitoba, 2002.

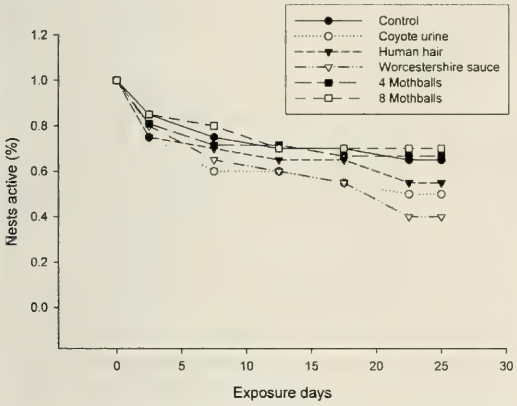

FIGURE 2. Percent of surviving artificial duck nests (all eggs remaining in nest) treated with scents at X exposure day in Manitoba, 2002.

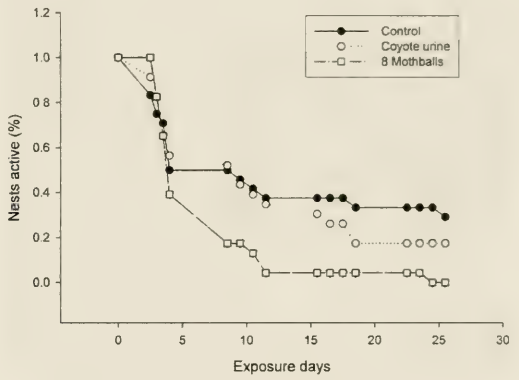

FIGURE 4. Percent of surviving natural duck nests (all eggs remaining in nest) treated with scents at X exposure day in Manitoba, 2002.

and Worcestershire sauce) or from their commercial claims (DEER-D-TER™ and mothballs). Nests in the control group were each treated with 0.1 L of marsh water, which was poured along the outside edge of the nest. A packet of DEER-D-TER™ was placed on the outside edge of each nest of the second group. DEER-D-TER™ consisted of a green plastic packet containing a mixture of sand and Coyote urine and was advertised to repel deer (*Odocoileus* spp.) and skunks. According to the manufacturer, this product was effective in the field for ca. 90 days. Group three received one cup of human hair which was collected from three different salons and was combined to create a homogeneous mixture. Group four received 0.15 L of Worcestershire sauce applied evenly to each egg and was reapplied on every subsequent visit. The fifth group received four mothballs double wrapped in cheesecloth to prevent accidental ingestion by ducks or predators. The sixth group received eight mothballs, to determine if a greater amount yielded a different or stronger response, with two cheesecloth-wrapped groups of four mothballs placed on opposite sides of the outside edge of the nest. Three groups of substances were applied to natural nests: marsh water, DEER-D-TER™, and eight mothballs. Methodology and application of treatments for natural nests followed the same protocol as those of artificial nests.

Data were collected from 12 June to 7 July 2002. Artificial nests were created by depositing six medium-sized chicken eggs in a depression which was then covered with grass. Nests were marked by a thin welding rod at a distance of 1 m. To avoid biases associated with

habitat, all artificial nests were deployed in rights-of-way. Each nest was randomly placed within a 0.8 km stretch along four different, but intersecting, secondary unpaved grid roads. Artificial nests were located 300-1000 m apart on alternating sides of the road. Nests were placed in the densest vegetation as close as possible to the randomly selected location to reduce possible effects of concealment on survival. Artificial nests were visited every five days for 25 days and were approached from a different angle each visit to avoid the creation of a pathway to the nest. Rubber boots and latex gloves were worn at all times in hopes of concealing human scent. Each nest was randomly assigned one test substance until an equal number of nests per treatment was obtained.

Natural nests were located via the drag chain method. Only upland areas of dense nesting cover were searched and nests were marked with stakes placed 10 m away in a random direction. Nests were located on four separate quarter sections within 1.6-8.0 kilometers of each other. Each quarter section consisted of dense nesting cover and was bordered by either a crop or fallow land and a secondary gravel road.

Treatments of natural nests were assigned systematically because we were unaware of how many nests we would eventually locate and we sought to have a similar number of nests per treatment. If, on return to nests treated with mothballs, any of the mothballs had fallen out of the cheesecloth, the entire packet was replaced with a new one. Hens often incorporated the wrapped mothballs into their clutch and occasionally moved the packet(s) directly (< 0.5 m) outside of the nest bowl. In these cases, the wrapped mothballs were left where the hen placed them. The first re-visit to the nest occurred between five and eight days after initial location and treatment application. Subsequent visits were made every seven days for up to a total of five visits depending on the fate of the nest. Natural nests were excluded from the analyses if they were abandoned but not depredated. However, we were unable to determine whether a nest had been abandoned and subsequently depredated.

All nests were deemed depredated (failed) after at least one of the eggs was removed from or destroyed in the nest. Mayfield logistic regression (Hazler 2004) was used to determine whether the nest survival of each treatment group differed from the nest survival of control nests within each nest type (artificial or natural). Because nests were not visited daily the exact date of failure was unknown. The number of days a nest was active ("exposure days") was calculated differently depending on the fate of the nest. Exposure days of nests that hatched (or survived to the last day of the study in the case of artificial nests) was the number of days that nest was under observation. Exposure days of failed nests was the number of days the nest was known to be active plus the midpoint between the last check and the last known active day. Nests that fail early are less likely to be detected and the Mayfield logistic regression reduces this bias by incorporating exposure days. Also, because this is a logistic-regression analysis, covariates can be incorporated, allowing for easy analysis of experimental data (Hazler 2004). All artificial nests were deployed on the same day and nest dragging was completed within three days which minimized the potential impact of seasonality on the data. An analysis of variance with repeated measures was used with respect to nest survival as a function of exposure days to determine whether there was a difference in the chronology of predation events between treatments as time progressed. All post-hoc tests were conducted using an all-pair-wise comparison Tukey test. Survival of artificial and natural nests was compared using Mayfield logistic regression.

Results

Survival of eggs in artificial nests was higher than that of natural nests (Wald $\chi^2_{df=1} = 43.4$, $P < 0.001$). Artificial nest daily survival was 0.54 (SE ± 0.003) for all substances combined, while daily nest survival for natural nests was 0.04 (SE ± 0.01) for all substances combined.

We deployed 120 artificial nests, with each treatment group containing 20 nests. Due to flooding, seven artificial nests were lost at various phases of the experiment and were excluded from further analyses. We found no significant difference in artificial nest survival rates among treatment groups (Wald $\chi^2_{df=5} = 4.5$, $P = 0.48$; Figure 1).

For all treatments combined, there was a positive correlation between survival of artificial nests and exposure days, with survivorship of nests increasing with time ($F_{4,25} = 6.77$, $P < 0.001$) and the first five exposure days being the most fatal (Figure 2). Additionally, the chronology of predation differed among groups ($F_{4,5} = 40.3$, $P < 0.001$). Artificial nests containing both four and eight mothball treatments were depredated similarly to control nests ($q = 1.63$, $p = 6$, $P > 0.05$; $q = 1.40$, $p = 6$, $P > 0.05$). However, nests treated with DEER-D-TER™ ($q = 9.14$, $p = 6$, $P < 0.05$), human hair ($q = 4.84$, $p = 6$, $P < 0.05$), and Worcestershire sauce ($q = 13.9$, $p = 6$, $P < 0.05$) were depredated more quickly than control nests.

In total, 70 natural duck nests were located, with 24 receiving the control, 23 treated with DEER-D-TER™, and 23 treated with eight mothballs. Natural nest survival of the treatment groups differed from that of the control (Wald $\chi^2_{df=2} = 11.82$, $P < 0.005$; Figure 3) with survivorship of nests treated with eight mothballs being significantly lower (Wald $\chi^2_{df=1} = 11.47$, $P < 0.005$).

Nest survival did not vary as a function of exposure days for all natural duck nests combined ($F_{3,8} = 2.14$, $P = 0.17$) despite a notably rapid decrease in nest sur-

vival during the first five exposure days (Figure 4). Nest survival did not vary as a function of exposure days among treatments for natural duck nests ($F_{3,8} = 1.99$, $P = 0.22$).

Discussion

We assessed the effect of various scent treatments on the survivorship of artificial and natural duck nests in the prairie pothole region of Canada. The application of scents did not increase nest survival of artificial or natural nests. Addition of mothballs decreased survival of natural nests. These results not only indicate that DEER-D-TER™, human hair, Worcestershire sauce, and mothballs were ineffective at repelling predators, but that certain scents may actually attract predators and/or increase duck nest abandonment rates.

The chronology of predation differed among treatments for artificial nests but not for natural nests. Contrary to expectations, artificial nests treated with DEER-D-TER™, human hair, and Worcestershire sauce were depredated more quickly than control nests. Again these results may indicate a neophilic predator response. In particular, human-associated scents (i.e., hair and food items) may elicit predator attraction depending on the study site and the animal's experience with people. Although this study took place in a rural location, it is plausible that local predators may have positive associations with human dwellings and food, especially opportunistic species such as Striped Skunks and Raccoons (Pitt et al. 2008). Raccoons in particular often rely on anthropogenic foods at the northern edge of their range distribution (Larivière 2004; Pitt et al. 2008). Additionally, DEER-D-TER™ may have also attracted predators to nests, especially con-specifics. Mothballs and hair regularly went undisturbed at depredated nest sites whereas urine packets were often chewed on and/or ripped open.

The result of predators exhibiting neophilic tendencies may have important implications for waterfowl due to the propensity for which they are studied. The concealment of human scent should be an important consideration for researchers. Neophilic predators may increase their search radius when a particular scent cue is present (Whelan et al. 1994), possibly rendering human-visited nests more susceptible to predation.

Our study indicates that the survival rates of artificial and natural duck nests in the prairie pothole region are different and this may indicate that these nests are viewed differently from the perspective of a predator. Artificial nests realized higher survival rates compared to natural nests, which has been previously documented (Guyn and Clark 1997). The disproportionate difference in survival between artificial and natural nests could also in part be attributed to the presence of scents associated with natural nests, as well as the presence of a hen and the ability to cue in on the nest after a flush event (Larivière and Messier 1997). Alternatively, the observed difference may have been mediated by uncontrolled factors affecting natural nest survival, such as nest abandonment, hen species and behavior, nest concealment, and variation in nest spacing. Specifically, the eight mothball treatment may have provoked abandonment by nesting female ducks as some ejected mothballs from nests.

Conditioned taste aversion has been effective in deterring predators from nests (Nicolaus 1986; Conover 1990). Napthaldehyde (the noxious substance in mothballs) has been found to be effective in causing adverse responses by Coyotes when ingested (Hoover and Conover 1998). After repeated exposure, Coyotes avoided eggs injected with napthaldehyde. Although highly successful, it is expensive and time consuming to set up nests with injected chemicals. For future studies, it may be equally effective and less time consuming to combine the use of conditioned taste aversion with scents. Our results indicate that applied by themselves, these scents do not increase survival of either artificial or natural duck nests.

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Translocation and Recovery Efforts for the Telkwa Caribou, *Rangifer tarandus caribou*, Herd in Westcentral British Columbia, 1997–2005

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During 1997–1999, 32 Woodland Caribou (*Rangifer tarandus caribou*) were translocated from the Sustut Herd to the Telkwa Mountains in westcentral British Columbia to augment recovery of the Telkwa Caribou Herd. The animals were fitted with radiocollars and located during 1997–2000 to determine selection of habitat features and terrain variables. Six Caribou calves were also collared to determine causes and timing of calf mortality during summer 1999. Defining available habitat for newly translocated animals is often arbitrary and subjective, and we based the analyses on ranks for habitat use and availability as this is less sensitive to the inclusion or exclusion of a questionable resource. This method represents some loss of information but provides indications of the relative importance of various habitat types without classifying any as avoided. High elevation habitat (> 1700 masl) on moderate slopes (16 – 45°) received the highest ranks, as did "warm" (136 – 315°) aspects and forests > 250 years old. Three calves died shortly after birth. One calf appeared to have been killed by predation, likely by a Golden Eagle (*Aquila chrysaetos*), and one calf was abandoned by the cow. Cause of death for the third calf is unknown. To assess habitat use associated with calving we compared summer locations with data obtained throughout the rest of 1999 for eight cows with calves and eight without calves. We found significant difference in use of elevation during calving time, when cows with calves remained at high elevations and barren cows generally descended to lower elevation habitat. Surveys conducted in 2005, five years after the completion of the initial study, produced a count of approximately 90 Caribou. This suggests that in the short term, the translocation was successful in re-establishing a self-sustaining Caribou population in the Telkwa Mountains.

Key Words: Woodland Caribou, *Rangifer tarandus caribou*, calf mortality, calving habitat, habitat selection, rank analysis, wildlife management, British Columbia.

Woodland Caribou (*Rangifer tarandus caribou*), populations have generally experienced decline and range reduction over the last century in British Columbia (Heard and Vagt 1998), across Canada (COSEWIC 2000*) and throughout the circumpolar region (Mallory and Hillis 1996). Causes of decline include a combination of habitat loss, habitat fragmentation, increased human access, hunting and predation (Bloomfield 1980; Edmonds and Bloomfield 1984; Heard and Vagt 1998), poaching (Edmonds 1988), and possible interactions between disturbance and predation (Mallory and Hillis 1996). Woodland Caribou in the Southern Mountain National Ecological Area of British Columbia (including the Telkwa Caribou Herd) were designated as threatened in 2000 (COSEWIC 2000*). Caribou were once widely distributed throughout the mountainous areas surrounding Telkwa and Smithers, British Columbia, and might have formed part of a larger herd whose range extended south into Tweedsmuir Provincial Park (TCHRP 1998*). Few data are available on the Telkwa Caribou Herd before 1997; however, surveys indicated fluctuations in herd size from less than 100 in 1949 to a high of 271 in 1965. A hunting closure was implemented for the herd in 1973 but only 68 animals were counted in 1984 (van Drimmelen 1986*) and monitoring flights in the 1990s resulted in counts of less than 20 Caribou (TCHRP 1998*). During 1997–1999, 32 Caribou were captured from the Sustut Herd about 150 km north of Smithers and translocated to the Telkwa Mountains to help the recovery of the Telkwa Caribou Herd.

Translocation is now a common tool in the recovery of populations at risk (Griffith et al. 1989) and the need for documenting habitat use and availability is critical in efforts to preserve endangered species and manage small populations (Manly et al. 1993). We studied habitat use and calf survival of the Telkwa Caribou Herd from 1997 to 2000 to determine preliminary habitat selection of translocated animals and assess timing and causes of calf mortality. With small populations following a translocation, there are usually limited data available to investigate habitat selection, and therefore little or no information for land managers. Although defining available habitat for newly translocated animals is often arbitrary and subjective, a preliminary evaluation of habitat selection can provide some infor-

mation on priority areas for protection when assessing other land uses such as forestry and recreation. Translocation success can be evaluated in three phases: (1) initial occupation and reproduction in the new ecosystem; (2) presence of a short-term self-sustaining population, and (3) ultimate population recovery (Compton et al. 1995). We outline findings on habitat selection and calf mortality between 1997 and 2000 and report for phases 1 and 2 of the Telkwa Caribou Herd Recovery Project. We also discuss challenges involved in providing habitat management priorities based on preliminary data from a small reintroduced population.

Study Area

The study area comprises approximately 25 000 km^2 in westcentral British Columbia, with elevations ranging from 300–3000 meters above sea level (Figure 1). It is situated between 53.40 and 55.20 degrees of latitude north and 125.10 to 128.30 degrees of longitude west. Glaciers, rugged peaks, high alpine plateaus, and deep glaciated U-shaped valleys with extensive wetlands characterize the alpine areas. Major tree species in the study area include Subalpine Fir *(Abies lasiocarpa)*, Engelmann Spruce *(Picea engelmannii)*, and Hybrid White Spruce *(Picea glauca × engelmannii)*. The climate has both coastal and inland influences, with cool summers and moderately cold winters. Precipitation averages 500 mm per year, of which about half falls as snow. The Telkwa Mountains have a population of approximately 250 Mountain Goats (*Oreamnus americanus*), and lower elevations have populations of Moose (*Alces alces*), Mule Deer (*Odocoileus hemionus hemionus*), and some Elk (*Cervus elaphus*). Large predators within the range of the Telkwa Caribou Herd include: Grizzly Bears (*Ursus arctos*), Black Bears (*Ursus americanus*), Wolverine (*Gulo gulo*), Wolves (*Canis lupus*), Coyotes (*Canis latrans*), and Golden Eagles (*Aquila chryseatos*). To account for the difficulty in defining available resources for the herd and thus delineating our study area, where most animals have had < 2 years of experience, we selected an area of available habitat based on three factors: (1) locations of collared caribou 1997-1998 (G. Schultze, British Columbia Ministry of Environment, personal communication); (2) Traditional Ecological Knowledge of the Telkwa Caribou Herd (B. Holland, Wet'suwet'en First Nation, personal communication in Stronen 2000) and (3) availability of forest cover data from the British Columbia Ministry of Forests (Inventory Branch, Victoria, scale 1: 20 000).

Methods

We located radiocollared animals throughout the year from fixed wing aircraft (Cessna 206, 185, or 172) using standard telemetry equipment. Tracking intervals varied from every four days to every three weeks, depending on funding, season, and weather conditions. We determined geographic location using yoke-mounted, handheld, or panel-mounted Global Positioning System (GPS) units and noted habitat characteristics, activity, group size, and presence of young. The accuracy of relocation data was tested and averaged ± 300 meters. Most locations were determined during morning or mid-day. For the purpose and scale of this study, the data were assumed representative of Caribou habitat use for day and night. Six calves were captured shortly after birth and equipped with radiocollars during the summer of 1999. Caribou calves were captured as close to within 24 hours of birth as possible using a Bell 206 Jet Ranger and a Long Ranger helicopter and a capture crew of three people. Calves were sexed, weighed, and fitted with VHF radiocollars (Lotek Engineering, Newmarket, Ontario) with motion sensitive mortality sensors. We estimated age by assessing the presence/condition of the umbilical cord, condition of hooves and pelage, posture, and general appearance (Haugen and Speake 1958; Miller et al. 1988), and calculated weight by subtracting 0.6 kg for each day of estimated age (Adams et al. 1995). Handling time was approximately five minutes from capture to release. Calves were monitored daily, weather permitting, from date of capture until the end of August. During September and October, we monitored calves weekly and after October they were monitored as a part of regular telemetry flights for the herd. We investigated mortality signals via helicopter the day of discovery.

Data for elevation (meters above mean sea level), slope (%), and aspect (in azimuth measured from north) were derived from a Digital Elevation Model using Arc/INFO v. 7 software. Tiles from the Digital Elevation Model were merged to form a seamless grid covering the study area. Floating point grids were generated for slope and aspect and we created a variable combining elevation and slope. Data on habitat type (leading tree species or non-productive timber area), crown closure (%), and tree age (using leading tree species) were derived from Forest Cover Inventory Polygons (British Columbia Ministry of Forests, Inventory Branch, Victoria, scale 1: 20 000). Values for terrain and habitat variables were summarized (km^2) for the entire study area to determine percent availability of the various classes of each variable. Habitat availability was analyzed by the British Columbia Ministry of Environment's regional GIS data analyst, who also produced cartographic output. We used data collected between November 1997 and April 2000 to analyse habitat use and determined terrain and forest cover values for all telemetry locations. To assess habitat selection, we followed sampling design 2 of Manly et al. (1993), where individual animals were identified and the use of resources was measured for each individual, but availability was measured at the population level.

To assess habitat use associated with calving, we used locations for eight cows with calves (n = 123 locations) and eight without calves (n = 128 locations)

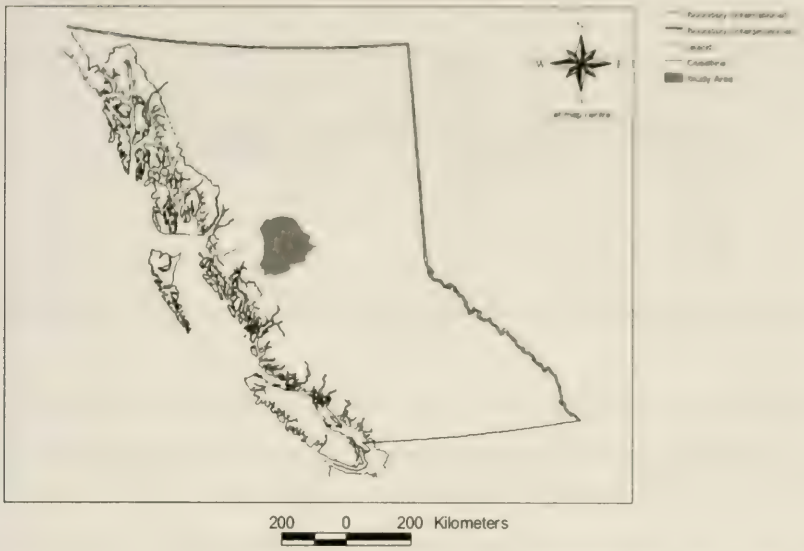

FIGURE 1. The study area in British Columbia, 1997 – 2000.

collected during the summer of 1999. We compared summer data (n = 150 locations) with locations obtained during the rest of the year (n = 145 locations) to account for differences not attributed to calving. Locations were divided into two groups:

(1) calving (25 May – 6 July)

(2) all-year (1 January – 24 May, and 7 July – 31 December)

We analyzed habitat selection using Resource Selection for Windows (RSW), a 32-bit Windows program for analyzing preference (Leban 1999). Using Johnson's (1980) method, which orders all variable components by rank for usage and availability, we measured habitat preference for each animal as the difference between the rank of usage and the rank of availability. We averaged these differences across animals to obtain a mean value for each habitat component and then compared the values to determine a ranking from least preferred habitat component to most preferred. We tested for habitat selection using alpha = 0.05. We compared habitat use of reproductive cows and cows without calves using analysis of variance (repeated measures, alpha = 0.05) within each group and within each season using SPSS 10.0 (SPSS Inc. 1999). The herd consisted primarily of translocated Caribou during the study and we considered the radio-collared animals to be a random sample of the Telkwa Herd.

Results

High elevation habitat on moderate slopes (> 1700 meters above sea level, 16 – 45%) received the highest ranks (Table 1). Caribou also made extensive use of the steep rugged mountains in the Telkwa range (>1700 m, > 45%). Aspects 136 – 315° received the highest rank (Table 2). The rank values for aspect appear to contradict the information on use versus availability. However, data on use report only overall percentage of use, and taking behavior of individual animals into account; the 136 – 315° aspects receive the highest rank. Less than ⅓ of locations (405 of 1424) were in forested habitats (Table 3), and of these locations, forests > 250 years old received the highest rank.

For analysis within groups, we found a significant difference in mean elevation between calving time and the rest of the year for cows without calves, but not for cows with calves. For analysis within season, we found a significant difference in mean elevation for calving time but not for the rest of the year. Although sample sizes were smaller for calving time, both groups had a narrower range in elevation during calving and individual differences in elevation use were also higher during calving than the remainder of the year (Figures 2 – 5). Figure boxes represent the interquartile range containing 50% of the values, with a line showing the median value. Error bars represent the highest and lowest values, excluding outliers (extreme values). Most cows gave birth in alpine locations, in exposed areas free of snow. Of the 16 cows sampled, only cow #151 made extensive use of elevations below 1400 meters throughout the year (Figure 4).

Calving time for Telkwa Caribou ranged from 26 May until 10 June, and six Caribou calves were collared between 3 June and 10 June 1999. Five were males born to transplanted Caribou cows and one was a female calf born to the only resident collared cow. Average birth weight was 8.4 kg (range 6.9 – 9.4 kg). Three of the six calves died shortly after birth. One calf likely died from abandonment, whereas cause of

TABLE 1. Use, availability and rank of classes for elevation and slope. Telkwa Mountains, British Columbia, Canada 1997–2000. N = 1424

Elevation (m)	Slope (%)	Class	Locations	% use	% available	Rank
<1100	0 – 15	1	116	8.15	38.43	9
<1100	16 – 45	2	38	2.67	20.75	8
<1100	>45	3	4	0.28	6.40	7
1100 – 1700	0 – 15	4	166	11.66	17.98	6
1100 – 1700	16 – 45	5	303	21.28	9.71	4
1100 – 1700	>45	6	168	11.80	3.00	5
>1700	0 – 15	7	144	10.11	2.18	3
>1700	16 – 45	8	313	21.98	1.18	1
>1700	>45	9	172	12.08	0.36	2

TABLE 2. Use, availability and rank of classes for aspect. Telkwa Mountains, British Columbia, Canada 1997–2000. N = 1416[a]

Aspect (azimuth)	Class	Locations	% use	% available	Rank
136 – 315	1	627	44.03	47.24	1
316 – 135	2	789	55.41	48.23	2

[a] Areas of zero aspect (usually where relocation error positioned animals in water) are excluded.

TABLE 3. Use, availability and rank of classes for forest age. Telkwa Mountains, British Columbia, Canada 1997–2000. N = 405[b]

Forest age (years)	Class	Locations	% use	% available	Rank
1 – 40	1	18	1.26	8.47	4
41 – 100	2	84	5.90	17.82	3
101 – 140	3	105	7.37	14.85	2
141 – 250	4	161	11.31	24.60	5
>250	5	37	2.53	7.08	1

[b] Including only locations below tree line (1700 m).

death for the second calf appeared to be avian predation, most likely Golden Eagle. Cause of death for the third calf was unknown. The calf had remains of what appeared to be milk curds in the stomach and small amounts of vegetation. However, membranes inside the hide appeared dry and indicated dehydration. No signs of predation or scavenging were evident. We found adult tracks, likely made by the mother, circling the carcass. During the first year after the transplant (1998), we observed five calves in the herd. The following year, we saw one yearling in the herd, as well as 12 new calves and one cow with an extended udder, indicating she recently had given birth and lost her calf. We observed eight calves during the 1999 October calf count. Recent surveys of the herd found 16 cows with calves in October 2003 and 23 the following year. In October 2005 ten cows with calves were counted. However, the decrease in cow/calf numbers from 2004 to 2005 may reflect fewer functioning radio collars in the herd during 2005, thus increasing the probability that some Caribou groups went undetected (G. Schultze, personal communication).

Discussion

The Telkwa Caribou Herd appears to select high elevation habitat with moderate slopes, which corresponds with earlier observations (van Drimmelen 1986*; Bill Holland, personal communication in Stronen 2000). The herd uses gentle to moderate slopes throughout much of the year, which is common for Woodland Caribou (Edmonds and Bloomfield 1984; Seip 1990*; Terry et al. 1996; Wood and Terry 1999). However, use of steep slopes is also reported (Hatler 1987*; Terry et al. 1996). Woodland Caribou have been found using southern/warm aspects (Edmonds and Bloomfield 1984; Warren et al. 1996), northern/cool aspects (Warren et al. 1996) or to show no apparent selection (Seip 1990*). Use also varies between years and seasons (Terry et al. 1996; Wood and Terry 1999). When in forested habitat the Telkwa Caribou Herd appears to select old forests, which corresponds with other studies (Cichowski 1993; Terry et al. 1996; Wood and Terry 1999; Apps and Kinley 2000*). Woodland Caribou in British Columbia have been classified into two ecotypes (Stevenson and Hatler 1985). The north-

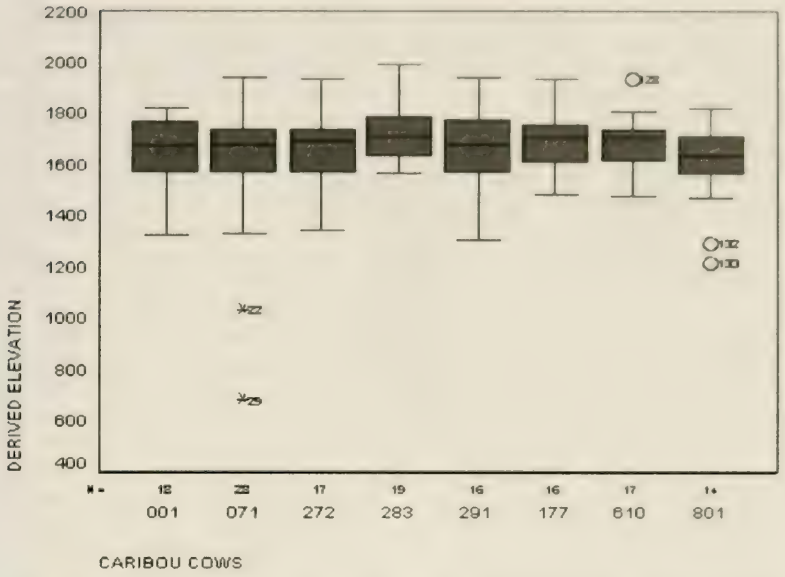

FIGURE 2. Barren cows' use of elevation all-year, 1999. Telkwa Mountains, British Columbia.

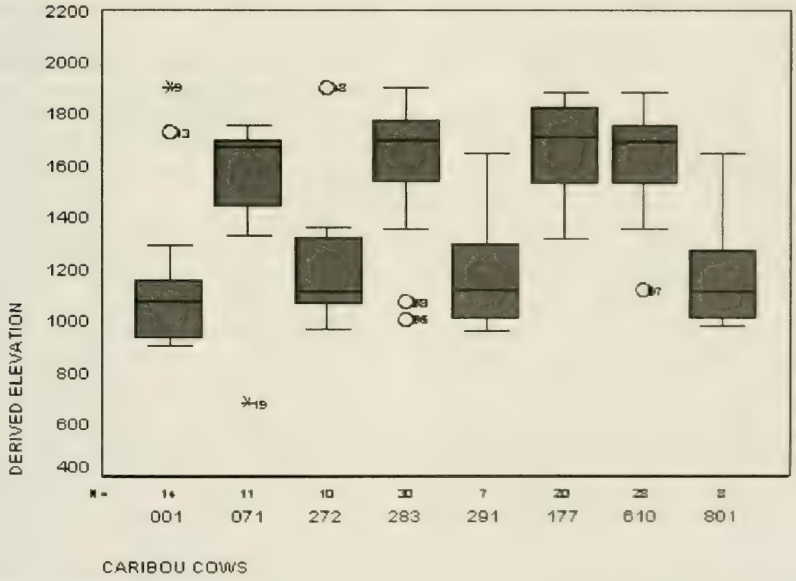

FIGURE 3. Barren cows' use of elevation at calving time, 1999. Telkwa Mountains, British Columbia.

ern ecotype (including the Telkwa Caribou Herd) depends primarily on terrestrial lichens during winter and the mountain ecotype depends more on arboreal lichens. Arboreal lichens are most abundant in old forest (Apps and Kinley 2000*), often on trees > 120 years old (Stevenson and Hatler 1985; Wood and Terry 1999). We found the Telkwa Caribou Herd in forested habitat only one-third of the time. However, divisions between arboreal- and terrestrial lichen-dependent groups are not absolute. The temporal impacts of icing, deep snow, and other environmental conditions may at times prevent Caribou from obtaining terrestrial lichens, making areas of arboreal lichens provisionally more important (van Drimmelen 1986*; Edmonds 1988; Cichowski 1993). Forests 141–250 years old received the highest use but the lowest rank. This is the most abundant forest age class (Table 3). Whereas the small number of Caribou during this study did not use this age class

in proportion to availability, the low rank does not equal avoidance or lack of importance. Future monitoring could also help clarify whether certain areas within this forest age class are locally important.

The difference in elevation use between barren and reproductive cows during calving season might be due to reproductive status. There are, however, wide differences within each group. As four of eight barren cows remained at high elevations (which presumably meant forgoing nutritional opportunities, at least in spring/early summer), this could be an antipredator strategy employed regardless of reproductive status. Based on this study, possible antipredator tactics for protecting a calf can not be distinguished from those that cows seem to use for their own protection. Edmonds and Smith (1991) reported that cow/calf pairs localised movement to relatively small geographic areas in early June (1-15) and did not increase the size of their ranges until after July. The Telkwa Caribou displayed similar behaviour, as cow/calf pairs in the Telkwa Herd remained relatively stationary until the middle of July. Subsequently, some pairs made long distance movements (one pair moved 50 km over a few days). The calving time for Telkwa Caribou corresponded to that reported by Edmonds (1988) for westcentral Alberta. As only one birth from a resident Caribou was recorded (10 June), it was not possible to examine any differences between transplant and resident animals.

Some cows in the Telkwa Caribou Herd appeared more sensitive to fixed-wing aircraft during the first couple of weeks post-calving than during the rest of the year, but we noted a wide range in behaviour. Cichowski (1993) reported that most adult females were found alone on ridge tops during calving. Two Telkwa cows calved on the top of a rocky ridge and were joined by two other cows with calves in the middle of June. The ridge had few access points but biophysical information suggests low potential for lichen production. All four calves were found alive in October. The use of ridges may be a trade-off between predator avoidance and the availability of abundant high protein food (Bergerud and Miller 1984). Cichowski (1993) found that most calving sites were within 10 km of previous calving sites and Seip (1990*) reported many Caribou use the same calving locations each year. We could not analyse fidelity to calving areas within the Telkwa Herd and it would take several years before this could be assessed. Caribou calving areas could change from year to year as an antipredator strategy (Bergerud and Miller 1984), and Valkenburg et al. (1988) warned against making management decisions based on Caribou calving areas located during narrow time intervals. However, previously known calving areas identified by the Traditional Ecological Knowledge of the Wet'suwet'en First Nation (B. Holland, in Stronen 2000) should be considered when making management decisions, as this information is based on years of observation and would indicate fidelity to specific calving sites.

Small sample size precluded analysis of calf mortality for the Telkwa herd but suggested that avian predation was a factor. Recruitment data from November 1998 to April 2000 seemed to indicate that low production of calves was a factor of equal or higher importance than the loss of calves. If the low recruitment of calves was due to calf predation, a higher frequency of Caribou cows with extended udders but without calves would be expected. Females without calves commonly shed their antlers in March and April and exhibit fresh antler growth during the calving period, whereas pregnant females shed their antlers near calving in May and June (Bergerud 1980). During our surveys at calving time, many cows exhibited fresh antler growth, indicating that they were not expecting a calf that year. The Caribou transplanted from the Sustut Caribou Herd would be expected to show pregnancy rates comparable to those of other populations when they arrived, and reported pregnancy rates usually range from 80% to 90% (Bergerud 1980; Seip 1990*; Edmonds and Smith 1991). It is possible that stress related to capture, immobilization, and transplant may have caused abortions or fetal absorptions, or that a large number of the cows were by chance not pregnant. In addition, there may not have been enough bulls to achieve normal pregnancy rates for the Telkwa herd during the first years. At least one resident mature bull was present in the herd during 1998 but due to difficulties associated with movement and collaring of adult bulls only younger males were translocated to the Telkwa Mountains.

Human activities such as recreation and resource extraction may also influence Caribou habitat use. Van Drimmelen (1986*) expressed trepidation over snowmobiling on the winter ranges of the Telkwa Herd and this has been a concern for over 25 years (Bustard 1977*). The presence of dogs may also cause Caribou to avoid otherwise useful habitat. This is particularly important during calving time, when cows may be extra sensitive to disturbance (Bergerud and Miller 1984). Need for information related to species translocations and/or small remnant populations will increase in the future. Where habitat availability is poorly estimated it may be particularly important not to label habitats and resources, which may be important in the long term, as avoided. We chose Johnson's (1980) method because it is relatively insensitive to decisions on what constitutes available habitat for the Telkwa Caribou Herd. If habitat components are used in proportion to availability, the rank ordering of use and availability will be the same. However, the converse is not necessarily true; the use and availability proportions could be different across habitat components, while still having the same rank, thus resulting in high Type 2 errors (where a difference in proportional selection is not detected) (Alldredge and Ratti 1986,

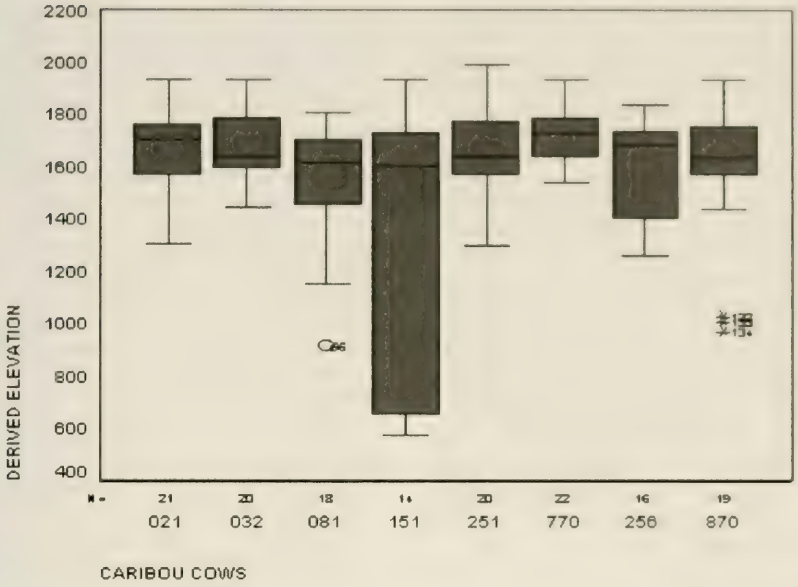

FIGURE 4. Reproductive cows' use of elevation all-year, 1999. Telkwa Mountains, British Columbia.

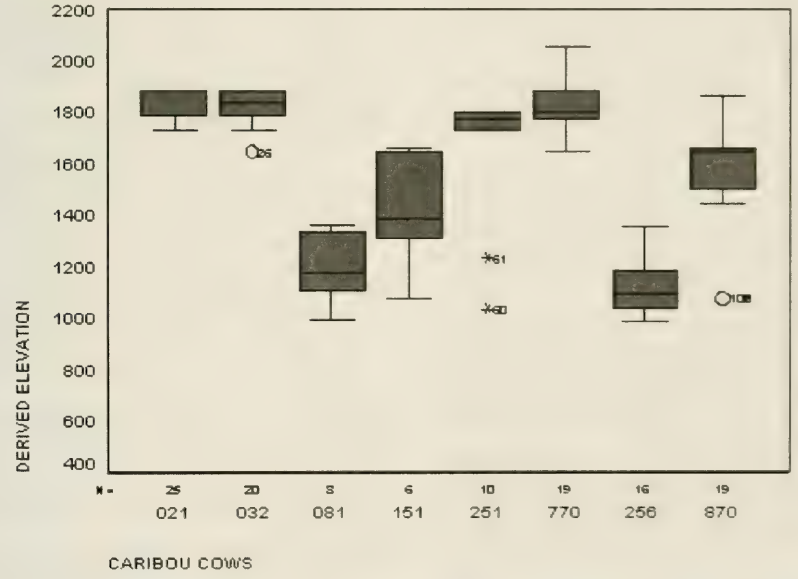

FIGURE 5. Reproductive cows' use of elevation during calving time, 1999. Telkwa Mountains, British Columbia.

1992). A bias may also occur against small habitat patches when the size of error area for locations [here ± 300 m] is independent of habitat patch size (Rettie and McLoughlin 1999). Many wetlands in our study area were too small to be captured in Forest Cover data and Houwers (1996*) reported that distribution of arboreal lichens in the Telkwa Mountains was patchy. These two habitat units, too small to be noted by our analysis, may be vital for long-term survival of the Telkwa Caribou Herd. The size of habitat required by Caribou to avoid predation may be significantly greater than the amounts required to obtain sufficient forage (Stevenson et al. 1994*; Seip and Cichowski 1996), and requirements for predation avoidance could be 10 times larger (Bergerud 1980). It is theorized that the Telkwa Mountains could support approximately

300 caribou (van Drimmelen 1986*). Given sufficient habitat and calf survival the herd could recover to historic numbers. At present, the translocation appears to have been successful in establishing a self-sustaining Caribou herd in the Telkwa Mountains.

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An Inventory of the Aquatic and Subaquatic Plants in SASKWater Canals in Central Saskatchewan, Canada, Before and After the Application of the Herbicide Magnacide

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Cota-Sánchez, J. Hugo, and Kirsten Remarchuk. 2007. An inventory of the aquatic and subaquatic plants in SASKWater canals in central Saskatchewan, Canada, before and after the application of the herbicide Magnacide. Canadian Field-Naturalist 121(2): 164–167.

This study focuses on the floristic composition of aquatic and semi-aquatic plants in the SASKWater canal system and their potential effect on irrigation systems. A checklist, evaluation, and synthesis of the species identified in this survey before and after the application of the herbicide Magnacide are provided, in addition to a brief discussion of the environmental effects of Magnacide. Thirty-three species in 26 genera within 20 plant families were identified. Two unidentified green algae were also collected. Common aquatics (i.e., green algae, *Potamogeton* spp., *Alisma gramineum*, *A. plantago-aquatica*, *Ceratophyllum demersum*, and *Myriophyllum sibiricum*) combined with debris from terrestrial plants were the primary contributors to blockage of irrigation drains. In general, the concentration of Magnacide used in this study had a minor effect on aquatic plant diversity, but effectively reduced plant density. However, the long-term effects of pesticides on the surrounding aquatic and terrestrial environments of the SASKWater irrigation system are unknown.

Key Words: aquatic plant inventory, environmental effect, SASKWater canals, Magnacide, acrolein, Saskatchewan.

Plants are vital to the function of aquatic ecosystems for their role in providing food, oxygen, and habitat for other organisms. However, floating and submerged vegetation along with debris from terrestrial plants may be problematic in different types of water bodies. For example, in shallow lakes, profuse plant growth creates dense mats that prevent the regular movement of watercraft. In addition, aquatic plants, including algae, can significantly reduce the aesthetic value of water bodies. Furthermore, rapid growth of vegetation and deposition of debris in irrigation canals can result in a decline in water flow rates and a subsequent inability to supply water to crops. Hence, the removal of selected aquatic species via physical or chemical methods may be required to improve ecosystem function, aesthetic value, and availability for human consumption.

Aquatic plants can be placed into four broad categories: (1) algae, (2) floating-leaved, (3) submerged, and (4) emergent plants (Shelton and Murphy 1989). Of the four categories listed above, algae are of the greatest concern in canal systems because of the likelihood of interfering with water flow. Algae grow profusely in slow moving, shallow water. Floating-leaved and submerged plants are rooted, with the foliage at or below the water surface. Flowing water or disturbance, such as wind, can uproot plants leading to subsequent obstruction of water flow. Finally, emergent species typically grow in shallow, fluctuating water, such as drainage ditches, canals, rivers, periphery of water bodies, and ponds. Plants in this category are of minor concern in canal systems and in some cases may prevent non-aquatic plant debris from entering the system.

Aquatic species impede water flow by clogging gates, intake screens, valves, and pumps in irrigation and drainage channels (Lancar and Krake 2002). As a consequence, localized flooding may result under high water conditions. In addition, Holm et al. (1969) indicate that abundant vegetation in canals can lead to an excessive loss of water through evapotranspiration. pondweed (*Potamogeton* L.), Milfoil (*Myriophyllum sibiricum*), Canada Waterweed (*Elodea canadensis*), wild celery (*Vallisneria* L.), and American Eel-grass (*Zostera marina* L.) are a few of the problematic coarse or large species in shallow aquatic environments (Lancar and Krake 2002).

Of particular interest to this study are aquatic taxa that interfere with canal irrigation systems in central Saskatchewan. Accelerated growth of plants in SASKWater canals restricts the amount of water available for irrigation. Given the clogging effect of aquatic plant growth on water flow, agricultural canals were treated with Magnacide, a volatile algaecide and aquatic herbicide, in which the active ingredient is acrolein (Scorecard 2006*). Acrolein contains two functional groups, a reactive double bond and an aldehyde group (Nordone et al. 1996) and is, in turn, toxic to some organisms (Albariño et al. 2007). However, it is widely used in agricultural canals and water bodies as an herbicide to control aquatic weeds (Burland et al. 1984; Sangodoyin and Smith 1996). The use of high concentrations of acrolein could pose a significant risk to aquatic environments (Nordone et al. 1996); therefore, the controlled application and use of Magnacide and other

herbicides is highly recommended. Previous studies have shown that toxic residues deposited in soils and water bodies have detrimental effects in the life cycles of local flora and fauna (Sangodoyin and Smith 1996). Thus, even though several sources, e.g., Sangodoyin and Smith (1996); Nordone et al. (1996); Albariño et al. (2007), claim that the transient use of acrolein in agricultural waters at minimal amounts has no negative impact in natural aquatic environments, rigid control must be enforced to prevent ecological damage.

In this study, we investigated the floristic composition of aquatic and semi-aquatic plants in the SASKWater canal system and their potential effect on irrigation systems. Our study is a contribution to the knowledge of Saskatchewan aquatic and sub-aquatic flora and provides a preliminary assessment and synthesis of the species identified prior to and after the application of Magnacide. The potential effect of Magnacide on aquatic flora is also discussed.

Methods

Compared to most wetland inventories, this survey covers a limited geographic area and a restricted range of wetland flora. The site selection and sampling strategy were designed to survey all major areas of the SASKWater canal system to be evaluated in terms of aquatic vegetation within the Saskatoon Southeast Water Supply Project Location Plan (Brightwater-Blackstrap-Zelma Reservoir areas; 51°25' to 52°55'N, 106°15' to 107°00'W). This system irrigates an estimated area of 20 120 acres. The survey sites include locations of Magnacide application by SASKWater personnel at intake screens. Acrolein was directly applied to water in strategic sites to control submersed, floating and emergent aquatic weeds. The herbicide was applied at a concentration of 2.5-5.0 ppm/30 minutes every two weeks from June through August 2005 in an attempt to eradicate aquatic species with excessive growth rates (J. Mander, SASKWater, personal communication). Surveys were conducted before and after the chemical treatment to determine the effect of Magnacide on the taxonomic richness and occurrence of aquatic plants in the canal system. Plant collections were conducted in 25-50 m areas before and after the point of application. Plants were pressed and identified in the herbarium of the University of Saskatchewan (SASK) using several local and regional references (Hotchkiss 1972; Larson 1993; Johnson et al. 1995; Moss 1996; Vance et al. 1984; Royer and Dickinson 1999). The plants collected were prepared as voucher specimens to serve as a permanent reference of this study in the SASK collection.

Results and Discussion

The survey indicates that the taxonomic composition of the SASKWater canals includes a total of 33 species in 26 genera and 20 plant families (Table 1). In addition, two different, unidentified, algae were collected (Table 1). Our survey also indicates that no plant species were eradicated from the sites as a result of Magnacide application; that is, the same species were identified before and after the treatment. However, the plant density was noticeably lower after the treatment with Magnacide. Various submerged species including *Potamogeton richardsonii*, *P. pectinatus*, and the unknown green algae were present in most of the sites surveyed. Other aquatics, e.g., *Elodea canadensis* and *Lemna trisulca*, were less frequent and accounted for a smaller proportion of plant biomass in the canal system. Emergent species in the Cyperaceae, Equisetaceae, and Asteraceae do not appear to play a role in impeding water flow, but floating debris from non-aquatic taxa, such as *Melilotus albus* and *Hordeum jubatum*, contributes to the clogging of intake screens throughout the canal system.

Based on this survey, it is not possible to determine a single species that adversely affects water flow by clogging intake screens in the SASKWater canal systems. A combination of common aquatic plants (*Potamogeton* spp., *Alisma gramineum*, *A. plantago-aquatica*, *Ceratophyllum demersum*, and *Myriophyllum sibiricum*), which are frequently dislodged by flowing water or wind, are the primary contributors to blockage of drains and intake screens. The presence of large, coarse water pondweeds such as *Potamogeton* spp. and other filamentous species in SASKWater canals is undesirable because their accumulation affects the regular water flow. A similar situation has been reported in the Alberta irrigation systems (Burland and Catling 1986). In addition, green algae are common and are presumably the greatest problem in clogging the intake screen systems because of their filamentous nature and massive growth. Furthermore, some plants or fragments from non-aquatic plants, particularly *Melilotus albus* and *Hordeum jubatum*, are involved in reducing water flow because the species tend to concentrate near the uptake areas, especially in the vicinities of mowed ditches along the canals.

Since this survey is mainly concerned with the floristic composition of the SASKWater canal system and the probable effect of some species on irrigation canals, only general comments can be made regarding the chemical treatment and subsequent effect in the aquatic and subaquatic plants. In general, the use of Magnacide at the concentration previously specified appears to have a minor effect on aquatic plants because species diversity before and after the application remained similar. This suggests that the amount of chemical applied is too low to notably reduce the growth and development of aquatic plants and possibly other non-target organisms. Acrolein is a contact herbicide; therefore, the root system is not damaged and plants quickly resume growth. This leads to the frequent re-application of acrolein (J. Mander, SASKWater, personal communication). Other studies, [e.g., Bowmer and Sainty (1977)], have shown that acrolein is effective in controlling aquatic plant growth, but no concentration rates are given. On the other hand, Sangodoyin and Smith

TABLE 1. Taxonomic list of the inventory of plants in the SASKWater canal system in south central Saskatchewan. The arrangement is alphabetical by family, then by genus and species.

Family	Species	Common Name
Characeae	Unknown green algae	
	Chara L.	
Alismataceae	*Alisma gramineum* Lej.	Narrow-leaved Pondweed
	Alisma plantago-aquatica L.	Broad-leaved Water Plantain
Apiaceae/Umbelliferae	*Sium suave* Walter	Water Parsnip
Asteraceae/Compositae	*Symphiotrichum lanceolatum* (Willd.) G.L. Nesom subsp. *hesperium* (A. Gray) G.L. Nesom	Western Willow Aster
Ceratophyllaceae	*Ceratophyllum demersum* L.	Hornwort
Cyperaceae	*Carex rostrata* Stokes	Beaked Sedge
	Eleocharis acicularis (L.) Roem. & Schult.	Needle-Spike Rush
	Eleocharis palustris (L.) Roem. & Schult.	Common or Pale Spike-Rush
	Schoenoplectus acutus (Muhl. ex Bigelow) Á. Löve & D. Löve	Great Bulrush
	Schoenoplectus tabernaemontani (C.C. Gmel.) Palla	
	Scirpus microcarpus J. & K. Presl.	Small-fruited Bulrush
Equisetaceae	*Equisetum palustre* L.	Marsh Horsetail
Fabaceae/Leguminosae	*Melilotus albus* Medik.	White Sweet Clover
Halogaridaceae	*Myriophyllum sibiricum* Kom.	Water Milfoil
Hydrocharitaceae	*Elodea canadensis* Michx.	Canada Waterweed
Lamiaceae/Labiatae	*Lycopus asper* Greene	Water Horehound
Lemnaceae	*Lemna trisulca* L.	Duckweed
Onagraceae	*Epilobium ciliatum* Raf.	Northern Willow Herb
	Oenothera biennis L.	Yellow-Evening Primrose
Poaceae/Graminae	*Glyceria grandis* S. Watson	Manna Grass
	Hordeum jubatum L.	Wild Barley
	Phalaris arundinacea L.	Reed Canary Grass
Potamogetonaceae	*Potamogeton filiformis* Pers.	Leafy Pondweed
	Potamogeton pectinatus L.	Sago Pondweed
	Potamogeton richardsonii (Benn.) Rydb.	Clasping Leaf Pondweed
	Potamogeton vaginatus Turcz.	Large-sheath Pondweed
	Potamogeton zosteriformis Fern.	Flat-stemmed Pondweed
Ranunculaceae	*Ranunculus aquatilis* L.	Thread-leaved Buttercup
Salicaceae	*Salix exigua* Nutt.	Narrow-leaved Willow
Sparganiaceae	*Sparganium* sp. L.	Bur-Reed
Typhaceae	*Typha latifolia* L.	Common Cattail
Zannichelliaceae	*Zannichellia palustris* L.	Horned Pondweed

(1996) caution that low concentrations of pesticides and agricultural chemical on surface waters have potential effects on fisheries and aquatic environments, but conclude that Canadian water sources in general exhibit concentrations of pesticides below the guideline limits, which suggests the proper use and handling of pesticides and herbicides in Canada. Nonetheless, more detailed research is required to draw conclusions on water quality issues.

Considering the losses and adverse effects to farming activities caused by obstructed canal systems, the control of aquatic plants is necessary in water bodies, particularly in areas with intake screens, so that irrigation systems can be most efficiently utilized. In addition to the chemical methods currently used for the eradication of aquatic plants, new research to implement a biological control program (involving perhaps an herbivorous species) of aquatic plants in irrigation canals should be conducted. Since numerous non-aquatic species clog irrigation systems, in our view, the most effective, environmentally friendly, and inexpensive strategy for maintaining levels of water flow for irrigation is to periodically manually clean intake screens and surrounding areas. Nonetheless, cautious and planned applications of chemicals such as acrolein (Bowmer and Sainty 1977), Endothall (Sisneros et al. 1998), and Hydrothall (Corbus 1982) may be effective to control excessive growth levels of species such as *Potamogeton pectinatus* and filamentous algae species.

Since several native, relatively poorly represented species are characteristic of these ecosystems, consistent monitoring is recommended to preserve wild natural resources. Furthermore, the long-term effects of pesticides on the surrounding aquatic and terrestrial environments of the SASKWater irrigation system are unknown. The current challenge is to assess the use of herbicides, in particular the long-term effect and impact of Magnacide residues, in the water quality, environment, and diversity of the wetland flora and fauna in Saskatchewan and other Canadian ecosystems.

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Life History of the Marine Isopod *Cyathura polita* in the Saint John River Estuary, New Brunswick: a Species at the Northern Extent of its Range

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The marine isopod, *Cyathura polita*, inhabits estuaries on the east coast of North America from the Gulf of Mexico to the Bay of Fundy, Canada. We studied *C. polita* in the Saint John estuary to test for potential differences in life history that might occur because of the northern location of the population. In the Saint John, based on our interpretation from a six-month sampling program (May-October), the population exhibits a three-year life cycle, one year longer than more southern populations, and stretching over four summers. Our study supported the occurrence of protogynic hermaphroditism. After two summers as juveniles, individuals matured as females during their third summer, then displayed sex reversal by becoming males that fall, and finally reproducing as males in their fourth summer of life before death. Mean length of *C. polita* from the Saint John was greater than individuals from more southern populations (females, 13.8 ± 2.14 mm; males, 16.3 ± 2.41 mm). Annual brood release occurred in late July-early August. Mean fecundity of females was 53.2 ± 18.9 embryos per brood, which was greater than found in southern populations. *Cyathura polita* is rare in Canada and is known only from the Saint John and along the northern shore of the Bay of Fundy to the border of the United States.

Key Words: Isopod, *Cythura politica,* growth, reproductive cycle, fecundity, protogynic hermaphroditism, status, St. John River, New Brunswick.

Our knowledge of life history evolution depends on understanding intraspecific variation in life history traits, such as those correlated with latitude. *Cyathura polita* (Stimpson, 1855) is a benthic isopod that occurs in estuaries along the Atlantic coast of North America from the Gulf of Mexico to the Bay of Fundy, Canada (Burbanck et al. 1979), and is an appropriate model for such a study. Latitudinal variations in life history traits have been demonstrated for *C. polita* populations from Florida to Cape Cod, and include adult size and life span (Burbanck and Burbanck 1979). Latitudinal differences in life history traits have been described in the common cyathuran of the eastern Atlantic, *Cyathura carinata*, among populations from Portugal to Sweden (Bamber 1985; Olafsson and Persson 1986; Marques et al. 1994; Cruz et al. 2003). In the present study, we investigated life history characteristics of *C. polita* for its northernmost known population in the Saint John River estuary, New Brunswick.

Cyathurans are interstitial isopods that live in burrows and feed on detritus and algae in the sediment (Burbanck 1959). They are eurytopic animals, tolerating wide fluctuations in conditions such as temperature and salinity, an adaptation suitable to estuaries. They are also an important indicator organism for healthy estuarine ecotones because they are usually present only in unpolluted waters (Burbanck and Burbanck 1979). Cyathurans in general do not swim as adults nor do they have a pelagic larval stage, resulting in populations that are relatively immobile, sessile and disjunct. According to Burbanck (1959, 1962a, b), *C. polita* inhabits estuaries where fresh and salt water mix over stable sediment containing gravel, silt and detritus. They are obligatory aquatic animals and cannot withstand long periods of dryness (Burbanck and Burbanck 1979). Often *C. polita* are located in transitional zones where cattails (*Typha*) and salt marsh grasses (*Spartina*) meet along the shoreline (Burbanck 1962b). They are an important food for ducks and fishes (Burbanck and Burbanck 1979; Dadswell 1979).

The life cycle of *C. polita* varies with latitude (Burbanck and Burbanck 1979). In southern populations, the life cycle duration is generally one year. In Florida, young are released from May to October, and grow over the winter until they mature and produce young the following spring and summer. Most southern cyathurans die at the end of their second summer (Kruczynski and Subrahmanyam 1978). In more northern locations, such as Cape Cod, the young are released in early summer (late June or early July), grow rapidly in the fall, and produce young the following year. In these populations some cyathurans die at the end of their second summer while others may survive a second winter and reproduce the following year, often exhibiting protogynic hermaphroditism (Burbanck and Burbanck 1979).

Cyathuran females carry their embryos in a ventral marsupium made of overlapping pairs of oostegites (Stromberg 1972). The embryos develop in the marsupium until they hatch from a vitelline membrane and are released into the environment as juveniles. This method of reproduction permits detailed study of fecundity and development in cyathurans, making the species an excellent model for life history studies.

Cyathura polita has been studied extensively in the United States, particularly in the southern states (Burbanck and Burbanck 1979). The Saint John River estuary and along the north Bay of Fundy shore to the United States border are so far the only known occurrences of *C. polita* in Canada, and these populations are located at the northern extent of its range (Burbanck et al. 1979, Atlantic Reference Center, St. Andrews, New Brunswick). We investigated the life history of *C. polita* in the Saint John River estuary, and compared these data to published observations to explore the hypothesis that northern cyathurans would exhibit differences in life history relative to those at southern latitudes. We suspected that, with probable slower growth in this population, body size of adults would be greater because of delayed maturity and the larger females would carry more embryos. Also, since this is one of the few Canadian populations of an organism which has poor powers of dispersal caused by its non-swimming life style and a brooding reproductive method, it may be important to characterize its life history for future reference under the Species at Risk Act. Finally, the Saint John River estuary is a unique habitat in Canada containing elements of Virginian, coastal marine ecosystems in the summer-warm shallows (Bousfield 1962; Burbanck et al. 1979; Dadswell 1979), boreal, marine species in its deep, fjord-like basins (Trites 1960; Carter and Dadswell 1983) along with the wide range of freshwater, diadromous, and marine species typically found in Atlantic Canada (Rogers 1936; Bousfield 1962; Gorham 1965; Gillis 1974).

Study Area and Methods

Samples of *Cyathura polita* were collected from the subtidal shore of the lower Saint John River estuary from four stations: Bell Point, Westfield Beach, Summerville and Millidgeville (Figure 1). This region is the junction between the Bay of Fundy and the Saint John River and both estuary outflow and tidal inflow are inhibited by a sill at the Reversing Falls. As a result, there are large fluctuations in salinity because of freshwater discharge, and inside the estuary tidal range is reduced to 0.5 m and summer surface temperatures are higher than in the Bay of Fundy (Metcalfe et al. 1976). The Saint John River has a salt wedge estuary combined with deep, fjord-lake basins, and surface salinities at the seaward end fluctuate throughout the year, falling to 0% during spring freshet and increasing to 20% during low freshwater flow (Metcalfe et al. 1976).

Samples were collected approximately bi-weekly, usually at low tide, from 29 May to 27 August 2004, with an additional collection on 10 October 2004. Samples of *C. polita* were collected randomly by removing the surface substrate from subtidal sites in water depths of 20 to 150 cm. Substrate was collected with a shovel, and sieved through 1 mm or 0.25 mm mesh. The smaller mesh size was used to capture juveniles too small to be retained by the larger mesh. Approximately 30 adults and 30 juveniles, if possible, were collected from each location during a sampling effort. Individuals were fixed on the day collected in 10% formalin buffered in sea water and transferred to 70% isopropyl alcohol within three days. On each collection date at each station, the water temperature at 0.5 m depth was measured using a mercury thermometer, and a 1L sample of surface water was collected for salinity measurements later in the laboratory. Sediment samples from each station (1L) were collected on 17 July 2004.

Salinity was measured using an YSI 30 Salinity meter, after calibration with a mercury thermometer. Sediment samples were analyzed for proportions of gravel, sand, and silt, using a sieve series where gravel was <38.1 mm, sand <2.0 mm, and silt <63 μm (Miall 2000).

Within a few days of capture, the total length of all individuals was measured to the nearest mm from the base of the antennae to the tip of the telson. Measuring the total body length was preferred to estimating size from prosomal length (Bamber 1985), for comparison with other literature on *C. polita*. Males were distinguishable by the presence of an appendix masculina on the second pleopod; females could be accurately distinguished only when with oostegites forming a brood pouch or marsupium (Figure 2). Individuals without these sexual dimorphisms were considered to be juveniles.

All gravid females with intact marsupia were analyzed for number and size of embryos. Embryos were removed from marsupia and classified into four stages of development based on electron microscopy (Mercer et al., *in press*): Class 1 embryos were round and contained within two membranes, the chorion and vitelline membranes; Class 2 embryos were elongated and showed differentiation of the three body regions (head, thorax, abdomen), but lacked differentiation of the appendages; Class 3 embryos were still housed within the vitelline membrane, but had considerable differentiation of appendages and head; and Class 4 embryos were hatched from the vitelline membrane and had well-differentiated appendages. Embryos were measured with a compound microscope to the nearest 17 μm.

Adults and embryos were prepared for scanning electron microscopy (SEM) with primary fixation in 2.5% glutaraldehyde (1 hr), followed by a post-fixation in 1% osmium tetraoxide (4 hrs, both fixes in 0.1M

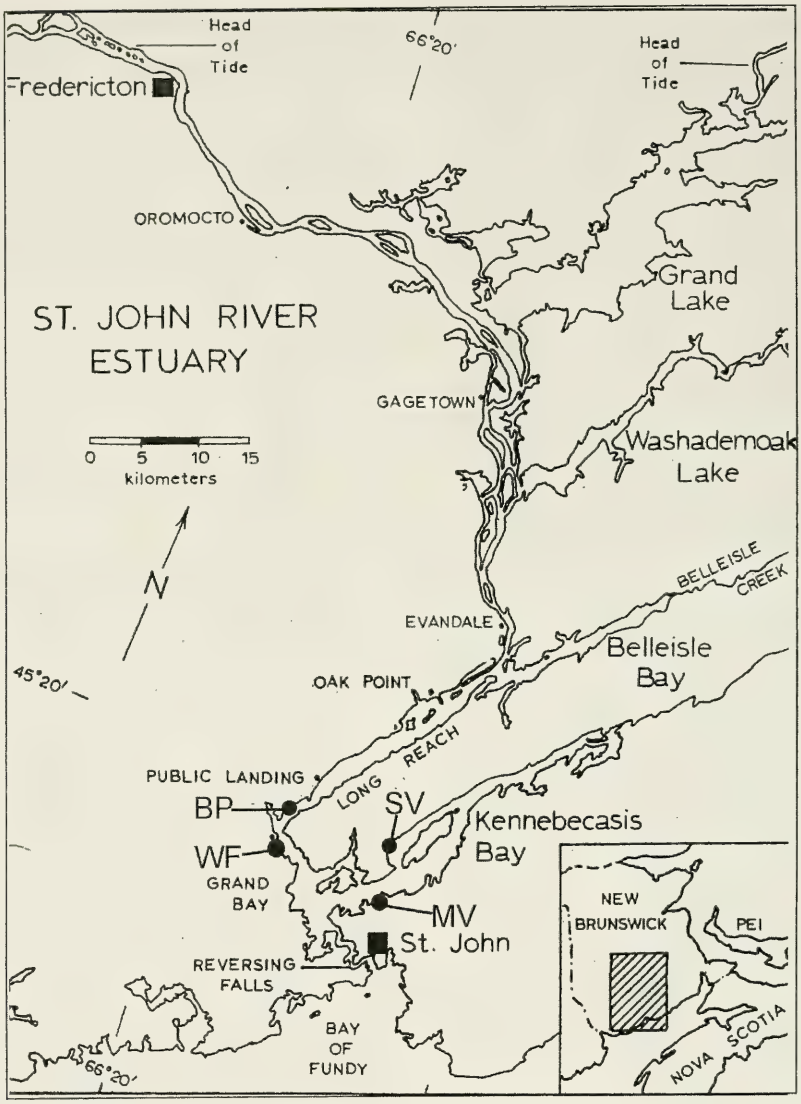

FIGURE 1. Map of the Saint John River estuary, with the four study locations indicated. BP = Bell Point; WF = Westfield; SV = Summerville; MV = Millidgeville.

cacodylate buffer in seawater). Tissues were dehydrated in an ascending ethanol series, critical point dried using a Bio-Rad E3000 critical point drier with liquid CO_2, and sputter coated with a Technics Hummer II sputter coater. Samples were viewed with a JEOL 5600LV Scanning Electron Microscope at 10kV.

Statistics were estimated with MINITAB 14, Microsoft Office Excel 2003, and SPSS 12. Graphs were plotted in Excel and SigmaPlot 9.0. Images were manipulated for size in Corel PhotoPaint 9 and labelled with CorelDraw 9.

Results

Water temperature, salinity and substrate were compared among all stations. For most of the study period water temperature ranged between 15 and 20°C (mean 19°C), with the highest temperature of 28°C on 17 July 2004 (Mercer 2005). Water temperatures at the four stations were similar on each collection date (one-way ANOVA, $P = 0.993$). Surface salinity ranged from 0.2 ppt in spring to a maximum of 6.6 ppt during mid-summer (Mercer 2005). However, mean salinity differed among the four stations (one-way ANOVA,

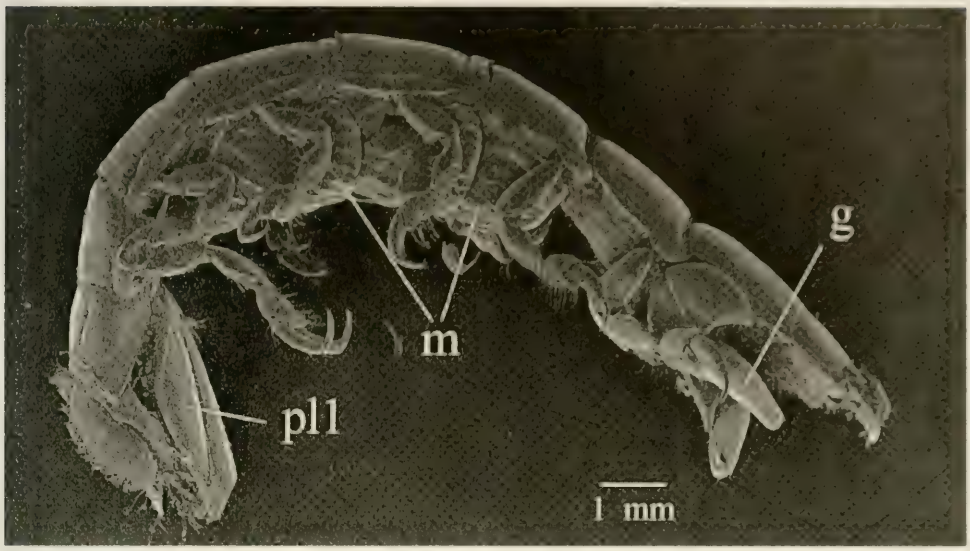

FIGURE 2. Scanning electron micrograph of a female *Cyathura polita* with marsupium, collected from the Saint John River during the summer of 2004. Symbols are: g = gnathopod, m = marsupium, pl1= 1st pleopod.

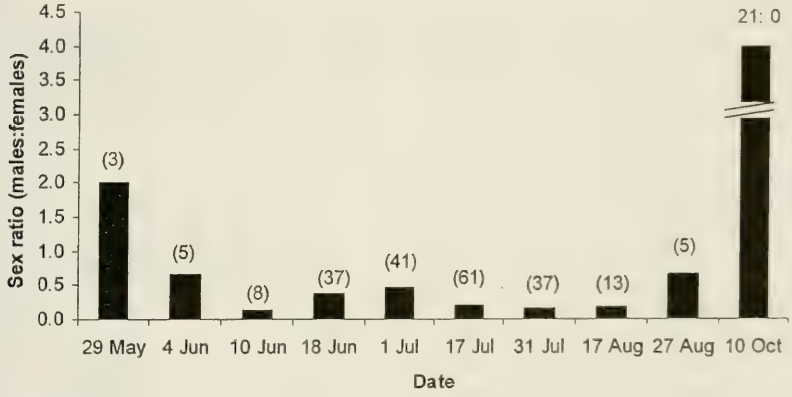

FIGURE 3. Male to female sex ratio of *Cyathura polita* during the study period in the Saint John River estuary. Data were pooled from four stations, and sample size (*n*) is given in brackets above each column. On 10 October, most adult isopods collected were male, resulting in a different scale, thus the sex ratio is given above the bar.

$P < 0.001$). Mean salinities at Bell Point (0.69 ± 0.31 ppt) and Westfield (1.5 ± 0.86 ppt) were similar (Fisher's 95% CI of -0.35, 0.78), while Millidgeville (4.7 ± 1.3 ppt) and Summerville (4.9 ± 1.5 ppt) were comparable (Fisher's 95% CI of -0.94, 0.19).

Sediment composition varied among the four study sites but all generally consisted of easily drained substrates (no anoxia; Mercer 2005). Bell Point had the highest gravel content of the four (84.5%), with little sand (15.1%) and hardly any silt (0.4%). Westfield had the highest percentages of sand (66.4%) and silt (7.3%) and the least amount of gravel (26.3%). Millidgeville contained more gravel (55.9%) than sand (43.5%) and very little silt (0.6%). Summerville was similar to Millidgeville with abundant gravel (47.1%) and sand (51.5%) and little silt (1.4%).

The sex ratio of *C. polita* varied during the study period, from a male:female ratio of 2:1 in May, declining to 0.5:1 in July, and increasing to 21:0 in October (Figure 3). In late spring, numbers of males exceeded females and large juveniles (probably maturing females) were present (Figure 4). From early June to the end of August, there were more females than males. Small, free-living juveniles, 2 to 3 mm in length, were first observed on 31 July 2004 numbers of presumably recently released from female marsupia. By the end of August, few distinguishable adults were collected at any station (Figure 4), but there were many

large juveniles (probably adults without secondary sexual characteristics). In October, despite the rarity of males during late August, there was an abundance of relatively large males (Figure 3).

Over the entire study, *C. polita* in the Saint John River estuary were an average of 10.1 ± 4.02 mm long, although the mean length varied among stations (Table 1). The mean length of all females collected was 13.8 ± 2.14 mm (n = 163) while males averaged 16.3 ± 2.41 mm (n = 68). Males were similar in length at all stations, as were females (Table 1; one-way ANOVA). Mean length of individuals collected from Bell Point and Millidgeville over the study period were similar, but isopods from both stations were significantly longer than those from Westfield and Summerville largely because the size of juveniles varied among stations (Table 1; one-way ANOVA). For three stations, mean juvenile length averaged 10.82 ± 2.50 mm while juvenile cyathurans from Summerville were smaller (8.60 ± 2.49 mm; Table 1). Most *C. polita* collected at Summerville throughout the study period were juveniles. This fact was highlighted when comparing the size of juveniles at Summerville (8.60 ± 2.49 mm in length) to the size of all individuals collected at Summerville throughout the study (8.71 ± 2.92 mm).

Seasonal changes in body length were estimated by comparing lengths of *C. polita* from each collection date, after sorting individuals by sex and reproductive stage (Figure 4). Since the physical characteristics were relatively similar among all stations growth data were pooled to assess life history. Females (with oostegites) were observed from 29 May to 27 August. Mature males were observed throughout the study, with peak abundance in late spring and early fall. Newly-released juveniles were first observed on 31 July and were abundant into the fall.

Cohort growth was estimated by comparing the mean length of each group of cyathurans at each collection date over the entire study period (Figure 5). Growth was estimated by extrapolating the mean length of each cohort in October back to the mean length of the next cohort in May. These estimates suggest that cyathurans from Saint John have a three-year life cycle, which spans four summer seasons. Young juveniles (Age 0) released from the marsupia at the end of July had a mean body length of 2.7 ± 0.25 mm and averaged 7.5 mm by October. Young juveniles grew approximately 0.07 mm/day, the fastest of all groups, where growth was represented by: $y = 0.068x - 11.9$ ($R^2 = 0.99$). The second cohort of juveniles (Age 1) had a mean length of 8.8 ± 3.4 mm in May and grew approximately 0.02mm/day were growth was represented by: $y = 0.018x + 6.44$ ($R^2 = 0.22$), resulting in a mean length in October of 12.4 ± 1.90 mm. Mature females (Age 2) were 11.0 mm mean length in May, and grew slowly at a rate of 0.01 mm/day where growth was represented by: $y = 0.009x + 11.3$ ($R^2 = 0.05$)

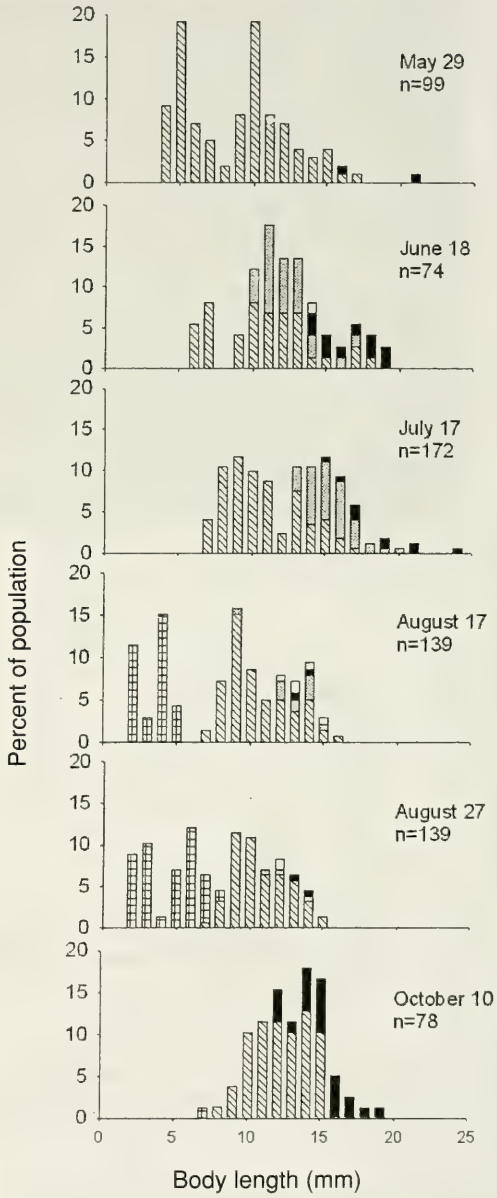

FIGURE 4. Size distribution of *Cyathura polita* in the Saint John River estuary for selected sampling dates during the summer of 2004, pooled from the four stations and grouped by sex and reproductive stage. New juveniles, horizontal bars; juveniles, cross-hatching; females, white; gravid female, stippled; males, black.

until they reached a mean length of 12.3 ± 1.53 mm by the end of August. Females grew little during the summer; however, it was the reproductive period, suggesting resources were partitioned into reproduction, not growth. The size distribution of male cyathurans

TABLE 1. Body lengths of *Cyathura polita* in the Saint John River estuary collected over the entire study period (29 May to 10 October 2004). Differences analyzed with a one-way ANOVA and a Scheffe post-hoc comparison among sites.

Location	N	Mean length ± SD (mm)	Minimum (mm)	Maximum (mm)
All isopods				
Bell Point	247	11.2 ± 3.06	2.5	19.0
Westfield	231	9.2 ± 5.00	2.0	21.0
Summerville	297	8.7 ± 2.90	2.5	19.0
Millidgeville	272	11.5 ± 4.20	2.5	24.0
one-way ANOVA df = 3, 1046, f = 35.90, p<0.000 (sites BP=MV>WF=SV)				
Males				
Bell Point	26	15.1 ± 1.77	12.0	18.0
Westfield	11	17.3 ± 2.57	14.0	21.0
Summerville	3	16.3 ± 2.51	14.0	19.0
Millidgeville	28	16.9 ± 2.54	13.0	24.0
one-way ANOVA df = 3, 67, f = 3.633 ns				
Females				
Bell Point	50	13.4 ± 1.87	9.0	19.0
Westfield	34	14.2 ± 2.38	8.0	20.0
Summerville	16	12.7 ± 2.79	9.0	18.0
Millidgeville	63	14.1 ± 1.91	9.0	17.0
one-way ANOVA df = 3, 162, f = 2.75 ns				
Juveniles				
Bell Point	136	10.6 ± 2.01	6.0	15.0
Westfield	96	11.4 ± 2.69	6.0	18.0
Summerville	262	8.6 ± 2.49	4.0	16.0
Millidgeville	149	10.7 ± 2.73	7.0	17.0
one-way ANOVA df = 3, 642, f = 43.75, $P < 0.000$ (sites BP = MV = WF>SV)				

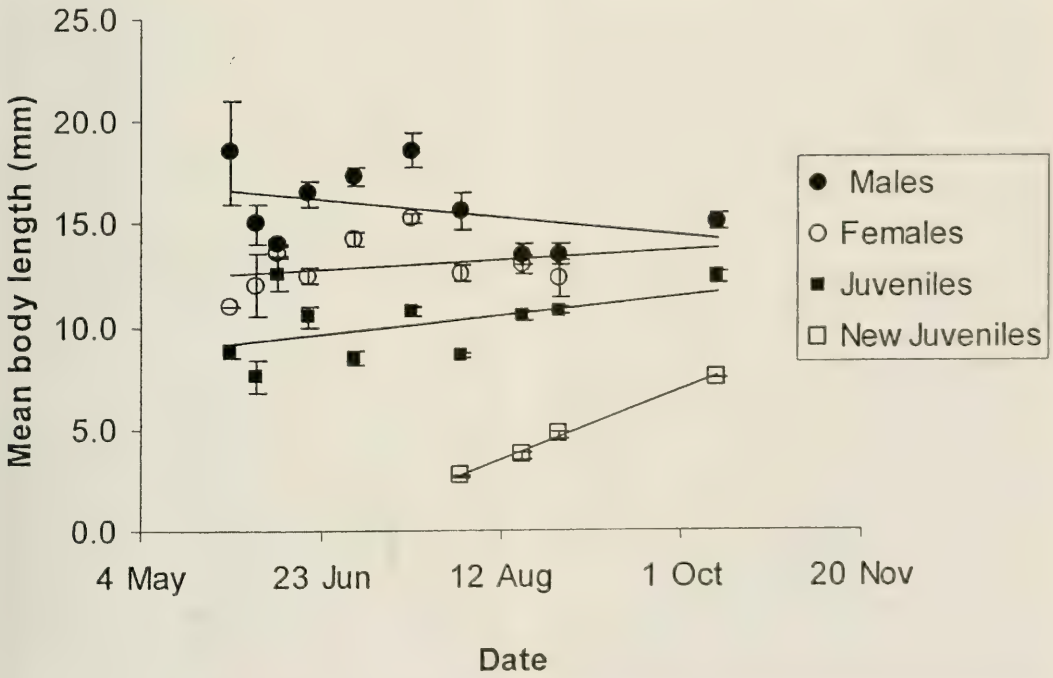

FIGURE 5. Mean length of *Cyathura polita* from the Saint John River estuary pooled from all stations at each sampling interval during the summer of 2004 and grouped by sex and reproductive stage. Vertical bars are standard deviations.

was very different from that of juveniles and females. Males (Age 3) were largest at the end of May (mean length 18.5 ± 3.54 mm), but smaller in October (mean length 15.1 ± 1.95 mm). A bi-modal size distribution during the growing season suggests the die-off of larger and older males in early summer, and the addition of new, smaller males in the fall as females underwent protogynic sex change or some large juveniles matured as males.

Other studies noted latitudinal variation in body length of *C. polita*, with individuals from more northern populations being generally larger than in southern populations. However, environmental conditions, such as the type of substrate or depth of water, may also strongly affect body size (Burbanck and Burbanck 1979). To assess whether cyathurans from Saint John followed this latitudinal trend, their mean body lengths were compared to values reported in the literature (Table 2). Females pooled from all stations had a mean length of 13.8 ± 2.14 mm (maximum: 20.0 mm), and males had a mean length of 16.3 ± 2.41 mm (maximum: 24.0 mm). These lengths were similar to cyathurans populations studied north of North Carolina, although none collected at Saint John were as large as the maximum length (27 mm) of the individuals collected from Chewonki Creek, Maine (Burbanck 1959). The individuals collected in the Saint John estuary differed markedly from southern populations such as Georgia and Florida: the largest male collected at St. Mark's, Florida, was only 1.8 mm larger than the smallest male collected in the Saint John (Kruczynski and Subrahmanyam 1978).

Broods were examined from 72 females, pooled from all four stations. Fecundity ranged from 16 to 98 embryos per brood, with a mean of 53.2 ± 18.9 embryos (Table 3). Abundant gravid females with embryos were first observed on 1 July. All of these broods contained early embryos (Class 1), with a mean length of 0.45 ± 0.06 mm. Two weeks later, more than half of the broods contained elongated Class 2 and 3 embryos, while the remainder contained Class 1 embryos. By the end of July, 50% of broods contained Class 4 young that had hatched out of their vitelline membranes but were still developing within the marsupia. By mid-August, only six gravid females were found: two had very large Class 1 broods and two had late-stage Class 4 broods. Within the marsupium, embryos grew from a mean length of 0.49 ± 0.08 mm as Class 1 embryos to a mean length of 2.07 ± 0.16 mm when they were ready to be released as juveniles. Class 2 and 3 embryos had a mean length of 1.05 ± 0.15 mm and 1.12 ± 0.19 mm, respectively (Table 3).

There was no correlation between female length and fecundity ($R^2 = 0.01$). There was also no effect of embryos/brood on embryo size ($R^2 = 0.01$) and little mortality within broods during development (Mercer 2005). Within-brood survivorship was 96.4% with only a slight decrease observed in mean embryos/brood when compared between Class 1 (57.9 ± 18.77 embryos/brood) and Class 4 broods (55.8 ± 19.64 embryos/brood).

Discussion

Cyathura polita from the Saint John River estuary exhibits several modifications in life history associated with its northern distribution. In particular, this population exhibits a longer life span, a shorter and later reproductive season, and produces larger adults with higher fecundity, in comparison to southern populations. Additionally, our data suggest that protogynic hermaphroditism occurs, as found in some other populations (Burbanck and Burbanck 1974).

In the Saint John River estuary, *C. polita* exhibits a three-year life cycle. Juveniles are released during July and August (Age 0) and, after little growth during the winter, remain immature the following summer (Age 1). Over the course of their second winter, juveniles develop into mature females (Age 2), which reproduce the following summer. Then, based on our length and sex ratio data, females either die or become males (Age 3) during the late summer-fall, and reproduce as males during their final summer of life. The result is a three-year life cycle, which spans four summers. In contrast, *C. polita* from southern populations have shorter life cycles. For example, in St. Mark's, Florida, *C. polita* are mature one year after hatching and reproduce throughout their second summer, suggesting a life cycle of less than two years (Kruczynski and Subrahmanyam 1978), while on southern Cape Cod, *C. polita* reproduce in their second, and sometimes third, summer, suggesting a two-year life cycle (Burbanck 1962a; Burbanck and Burbanck 1979).

Latitudinal changes in the duration and timing of reproduction are also evident. *Cyathura polita* reproduce from April to August in St. Mark's, Florida (Kruczynski and Subrahmanyam 1978), from June to July at Cape Cod, Massachusetts (Burbanck 1962a) and July and August in the Saint John estuary (present study). Although the breeding season is short and relatively simultaneous in the Saint John population, females were found with broods at different stages of embryonic development throughout the brooding period, especially in mid- to late-July.

The longer life cycle and delayed reproduction in northern cyathurans probably occur because of a shorter growing season. The population in the Saint John lives in water that averages 19.0°C during summer, but shallow water temperatures decline to near 0°C from December until April (Metcalfe et al. 1976). The result is limited opportunity for growth and reproduction in warmer waters, resulting in delayed maturation. In contrast, cyathurans from Florida live at temperatures ranging between 13.8° and 33°C, and above 20°C for ten months of the year (Kruczynski and Subrahmanyam 1978). Previous studies suggest that rapid growth in cyathurans occurs only during periods

TABLE 2. Summary of body lengths for *C. polita* reported in the literature, as means ± S.D. or range, depending on the source.

Location of study	Body length (mm)	Author(s)
Saint John, New Brunswick	♂ 16.3 ± 0.29	present study
	♀ 13.8 ± 0.17	
Marsh River, Maine	♂ 14 – 21	Haefner et al. 1969
	♀ 14 – 19	
Marshfield, Massachusetts	13.3 ± 0.33	Frankenberg 1962
Sapelo Island, Georgia	9.3 ± 0.64	Frankenberg 1962
St. Mark's, Florida	♂ 7.3 – 13.8	Krucsynski and Subrahmanyam 1978
	♀ 8.3 – 13.0	

TABLE 3. Fecundity and mean embryo length of *Cyathura polita* in the Saint John River estuary. Embryos were grouped by class of development where: Class 1 embryos were round and contained in two membranes, the chorion and vitelline. Class 2 embryos were elongated and differentiated into three body regions (head, thorax and abdomen). Class 3 embryos were within vitelline membrane but had differentiated appendages. Class 4 embryos were hatched from the vitelline membrane (Mercer et al. *in press*).

Date collected	Class of development	Number of gravid females	Fecundity Mean ± SD	Total number of embryos	Embryo length (mm) Mean ± SD
1 July	1	15	52.8 ± 22.48	956	0.45 ± 0.06
17 July	1	13	59.4 ± 11.08	658	0.52 ± 0.09
	2	14	47.0 ± 18.88	630	1.05 ± 0.15
	3	7	38.3 ± 14.21	207	1.10 ± 0.11
31 July	1	3	52.0 ± 22.61	181	0.52 ± 0.01
	2	1	23		1.03 ± 0.11
	3	7	50.5 ± 15.34	341	1.14 ± 0.24
	4	11	51.3 ± 24.18	540	2.06 ± 0.16
17 August	1	2	90.0 ± 11.31	180	0.59 ± 0.07
	2	1	4		1.07 ± 0.15
	3	1	57		1.13 ± 0.07
	4	2	33.5 ± 41.72	67	2.15 ± 0.18

of higher water temperature, and that growth ceases when waters cool (Olafsson and Persson 1986). The two-year life cycle described for Cape Cod may be more similar to the southern populations, perhaps because the southern side of Cape Cod, where the study was conducted, is more Virginian in nature than Boreal (Gosner 1971).

Cyathura carinata, common along the coast of Europe, exhibits a similar cline in life history traits. Studies of *C. carinata* in Portugal have suggested relatively short life cycles of 19 (Cruz et al. 2003) or 18 to 22 months (Marques et al. 1994). However, three-year life cycles are reported for *C. carinata* populations in more northern locations such as Poland (Jazdzewski 1969), Sweden (Olafsson and Persson 1986) and England (Bamber 1985). Olafsson and Persson (1986) suggest that *C. carinata* populations in Sweden require two years before juveniles are able to mature and reproduce, in contrast to southern populations, which are able to reproduce after one year. Bamber (1985) suggests that a longer life cycle is necessary in northern populations as the isopods cannot grow during the winter; whereas southern populations are able to grow continuously and attain mature size sooner.

Cyathura polita in the Saint John River estuary appears to exhibit protogynic hermaphroditism. Sequential hermaphroditism is rare in marine peracaridans, although relatively common in terrestrial and parasitic species (Johnson et al. 2001). Brooks et al. (1994) report that of the approximately 60 species of crustaceans known to be sequential hermaphrodites, only a few are protogynous, including three species of *Cyathura*, three other isopods and five species of tanaids. Evidence for protogyny from the present study includes sex ratio and adult size. Males were abundant in the population in May and again in October, but rare during summer when the majority of adults were females. Also, males in the fall were similar in length to spent females at the end of the summer (approximately 15 and 12 mm in length, respectively), while most large juveniles were smaller (approximately 10 mm in length). Males continue to grow during the fall and reach a length of approximately 18 mm in the spring of their final year. These observations support a model of protogynic hermaphroditism, whereby mature females become reproductive in early summer of their second year (i.e., third summer) and release juveniles during late July and August. After the release of young,

females molt, change sex, and function as mature males in their fourth spring and summer, before death.

The hypothesis that *C. polita* in the Saint John River are protogynic hermaphrodites is consistent with evidence of sex change reported from other populations under both laboratory (Burbanck and Burbanck 1974) and field conditions (Kruczynski and Subrahmanyam 1978). While it is possible that males migrate to other areas of the estuary after reproducing and return to shallow waters in the fall, previous work suggests that mostly immature cyathurans occur in the deeper waters of this estuary, while reproductive adults are in shallower water (Gillis 1974; Burbanck et al. 1979). Burbanck and Burbanck (1974, 1979) have reported that some primary males can develop directly from juveniles, which may account for some of the variation in sex ratios and body lengths observed here.

As hypothesized by Bamber (1985), it would be advantageous for male cyathurans to be larger than females to reduce their chances of mortality. Males are able to mate with more than one female, but need to leave their burrows in order to mate, thus they are at a greater risk of predation. Females do not need to expose themselves to that risk, and thus may mature at a smaller size. Warner (1988) additionally suggested that it would be advantageous to become male at a larger size if there is competition among males for females.

With a few exceptions, the development of embryos collected at Saint John was synchronized within a brood, which agrees with observations on cyathurans by Stromberg (1972) and Bamber (1985). Our observations suggest that the brooding period for females in the Saint John River estuary lasts from 30 to 45 days. Class 1 embryos were first observed in marsupia on 1 July. The first hatched embryos (Class 4) were observed on 31 July, which corresponds with the first appearance of new juveniles. While comparable observations are not available for more southern populations of this species, a 30 to 45 day brooding period may be typical for this genus. Olafsson and Persson (1986) found that a *C. carinata* population on the southern coast of Sweden had a three to four week brooding period, while others studying *C. carinata* in Portugal determined embryonic development to also last 30 to 45 days (Cruz et al. 2003).

Brood size is not widely reported for *C. polita*, however broods collected from Saint John were much larger (53.2 ± 18.9 embryos/brood) than broods from Florida (mean: 14 embryos/ brood, range 2-32; Kruczynski and Subrahmanyam 1978). A similar south-north cline is known in the European *C. carinata*. Bamber (1985) found that *C. carinata* females in England carry a mean of 29.8 embryos/brood (range 14-45), while *C. carinata* females in Sweden averaged 42 ± 12 embryos/brood (Olafsson and Persson 1986). The large brood size in Saint John *C. polita* is likely a function of increased female size because of greater age (3 vs. 2 years). Larger females would likely have larger marsupia and therefore may be able to carry more embryos.

Cyathura polita at the northernmost extent of its range exhibits several modifications in life history compared to more southern North American populations. These modifications are similar to those observed among European *C. carinata* populations. Our results support the existence of a latitudinal cline in life history traits in *Cyathura*, with implications for life span, size and fecundity. Plasticity in reproduction, coupled with protogynic hermaphroditism, makes *C. polita* an excellent model for studies of the effects of the environment on life history traits.

Cyathura polita is an important indicator of estuarine health (Burbanck and Burbanck 1979) and since the Saint John River estuary has one of the few populations in Canada there are compelling reasons to understand its life history and population size. We suggest a more comprehensive knowledge of the biology of this isopod in the Saint John could assist both with pollution monitoring and with further the distinction of the Saint John estuary as a distinct ecosystem in Canada. Future study of the Saint John cyathurans should be undertaken to verify the 3-year life cycle with sampling throughout the year and to define its estuarine distribution and abundance. *Cyathura polita* occurs as far inland in the Saint John estuary as Washademoak Lake (Figure 1; Burbanck et al. 1979) and it is a common prey of the Shortnose Sturgeon (*Acipenser brevirostrum*) another southern species that is endemic to this estuary in Canada (Dadswell 1979).

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Post-Emergence Movements and Overwintering of Snapping Turtle, *Chelydra serpentina*, Hatchlings in New York and New Hampshire

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Hatchling Common Snapping Turtles (*Chelydra serpentina*) were captured within, or as they emerged from, their nest cavities in Long Island, New York, and in southeastern New Hampshire. They were fitted with radiotransmitters and released at their nest sites. Their movements were monitored for as long as possible, which for some included tracking them to their overwintering sites and relocating them the following spring. On Long Island, all hatchlings initially moved to water. Later movements were both aquatic and terrestrial, and those that could be located while overwintering had left the water and hibernated in spring seeps, where they were recovered alive the following April. In New Hampshire, hatchlings moved directly to nearby aquatic habitats after emergence, where they spent the winter submerged in shallow water in root masses near banks.

Key Words: Common Snapping Turtle, *Chelydra serpentina*, hatchling turtles, hibernation in turtles, New York, New Hampshire.

In northern climates, the behavior of hatchling aquatic turtles, once they have pipped and left the eggshell, is variable both among and within species. In some species the majority of hatchlings remain in the nest until the following spring, although some fall emergence may occur. These include Painted Turtles (*Chrysemys picta* – Zwiefel 1989; Lindeman 1991; Pappas et al. 2000), Common Map Turtles (*Graptemys geographica* – Pappas et al. 2000; Baker et al. 2003; Nagle et al. 2004), and Diamondback Terrapins (*Malaclemys terrapin*; Baker et al. 2006). For the two former species, it is assumed that if the hatchlings leave the nest, they overwinter aquatically, while for the latter species fall emergence coupled with aquatic or terrestrial overwintering has been reported (Draud et al. 2004), as well as overwintering in the nest coupled with fall emergence (Baker et al. 2006). Other species have been consistently reported to be overwhelmingly fall emergers, including Snapping Turtles (*Chelydra serpentina* – Obbard and Brooks 1981; Carroll and Ultsch 2007), Spiny Softshell Turtles (*Apalone spinifera* – Christiansen and Gallaway 1984; Costanzo et al. 1995), Musk Turtles (*Sternotherus odoratus* – Cagle 1942; Mitchell 1988), Wood Turtles (*Glyptemys insculpta* – Harding 1991; Carroll and Ultsch 2007), Spotted Turtles (*Clemmys guttata* – Ernst 1976; Carroll and Ultsch 2007), and Blanding's Turtles (*Emydoidea blandingii* – Standing et al. 1997, 1999; Pappas et al. 2000). Hatchlings of most of these species are assumed to overwinter aquatically, even though some may remain on land for extended periods before entering the water; e.g., Wood Turtles (Tuttle and Carroll 2005; Castellano, Behler, and Ultsch, unpublished data) and Blanding's Turtles (Standing et al. 1997, 1999). However, there are some reports of suspected terrestrial overwintering in the hatchlings of some of these species, based largely on the capture of one or a few individuals in spring in microhabitats that are suggestive of non-aquatic overwintering (Ernst 1966, 1976; Standing et al. 1997; Pappas et al. 2000, Parren and Rice 2004). While such behavior does not appear common, its degree of occurrence is uncertain.

There are no reports of following individual hatchlings from the time of emergence from the nest until the resumption of activity the next spring. The typical approach of a study of overwintering behavior, a number of which have been done with adult turtles (reviewed by Ultsch 2006), has been the use of radiotelemetry, permitting tracking of the turtles throughout the hibernation period, including entrance and exit. Recently, transmitters small enough to attach to hatchlings have become available, which allows tracking of the animals from the nest to their wintering grounds, although battery life is not yet long enough to track the turtles until the following spring. However, once the turtles go into hibernation, they move little, which potentially allows recovery during the early spring before movement is resumed.

Here we report on the post-emergence and overwintering behavior of Snapping Turtle (*Chelydra serpentina*) hatchlings in Long Island, New York, and in southeastern New Hampshire. In both localities the hatchlings moved to water rather directly, but their eventual overwintering sites differed considerably at the two locations.

Methods

On Long Island, 15 Snapping Turtle hatchlings were collected in the nest on 11 September 2004 from two nest sites (seven from one and eight from the other) in the vicinity of Cold Spring Harbor, Nassau County. The nests were located along an earthen dam separating a lake from the stream formed by the dam overflow. They were brought to the laboratory, fitted with 0.9 g BD-2 transmitters (Holohil Systems Ltd., Carp, Ontario, Canada) attached to the carapace with cyanoacrylate glue (Krazy Glue®), and released into their respective nest cavities on 13 September 2004. All hatchlings left the nest cavity within 10 min. Telemetry commenced on 14 September, using a Communication Specialists model R1000 receiver. The expected life of the transmitters was 30 days, and some were replaced on day 30. Whenever possible, a visual location was paired with the telemetric location, which was recorded with a hand-held Magellan GPS 315. Hatchlings were located on nine days from 14-30 September, 10 days from 2-28 October, and on 5 and 12 November. Five hatchlings were lost during the study. Hatchlings that entered final hibernation sites were marked by surveyor flags for recovery, which occurred on 5 April 2005.

In New Hampshire, hatchlings were collected from both riverine and palustrine habitats. Six hatchlings were collected from a nest site 20 m from a third-order stream (riverine site) and 18 hatchlings were collected from two adjacent nests 3 m from a first-order stream (palustrine site) within a wetland complex. On 17 September 2005 six hatchlings from the riverine site were brought to the laboratory and fitted with 0.5 g A2415 transmitters (Advanced Telemetry Systems [ATS], Inc., Isanti, Minnesota) attached to the carapace with epoxy resin. They were released at the nest site on 19 September 2005. Hatchlings were located using an ATS FM-100 receiver and their GPS coordinates recorded using a Trimble Geoexplorer 3. At the palustrine site, nine hatchlings emerging from a nest (22 September 2005) were fitted on site with Holohil transmitters (see above) attached to the carapace using epoxy resin. These hatchlings were then returned to the nest. After a flash flood event during the first week of October 2004, 12 hatchlings were lost. At that time transmitters were attached on site to eight additional hatchlings captured at the site in shallow water. Hibernation sites were marked using surveyor flags. These sites were searched in March 2006.

Results

On Long Island, 10 hatchlings were followed. The transmitter became detached from three after their movement to water. Two others were found dead. One moved to the water and was found dead on a beach after 26 days. One exhibited considerable movement activity (34-260 m between location periods), including some terrestrial movements, and by 5 October had moved to a seep, buried in leaves near the surface; it was found dead there on 3 April at a depth of 5 cm. One moved into and out of water and then back into the water, and was located on 12 November dug into sand under a tree root in about 8 cm of water. This animal could not be located the following April.

Four hatchlings were tracked to their hibernation quarters and located the following spring. One moved immediately to water, then was found on 2 October under a log 8 m from water. By 10 October it had moved uphill to a spring seep, and two days later had dug to about 20 cm depth and did not move through 12 November. It was found alive and responsive at the same site on the following 3 April in 8 cm of saturated mud. A second moved directly to water and then emerged onto land on 30 September about 1.5 m from the water. By 2 October it had moved to a site about 20 m from the water, where it buried under leaves and remained until 8 October. By 10 October it had moved 15 m and was at the surface under cat briar. On 12 October it had moved to a second spring seep, where it buried, moved, and reburied over a 6-day period to depths of 10-13 cm. By 21 October it had relocated in the seep and buried to about 15 cm and had not moved by the last observation on 12 November. It was found alive and alert near the surface at the same location on 3 April. A third moved to water, and moved aquatically until 30 September, when it moved into the same seep area as the second, where it moved intermittently, being found buried at depths of 8-13 cm until 18 October, when it settled into the wet organic detritus along the side of a fallen tree, and had not moved by 12 November. It overwintered there and was found alive and well at the surface of the mud at the same site on 3 April. A fourth moved to and about in shallow water for five days. By the seventh day it had left the water and buried into moist sphagnum moss about 0.25 m from shore for 3-5 days without moving. It then moved back to water for 2-3 days and then back onto land on 30 September, where it buried for three weeks about 8 cm into the same seep used by the second and third hatchlings. It then moved downward to about 15 cm by 21 October and did not move through 12 November. It was recovered alive at this site on 3 April.

In New Hampshire, at the riverine site, 5 of 6 hatchlings moved first up a gentle slope and then down a steep slope to the river 6 m below. Three of these entered the river within 3 h of release, one after 24 h, and one after 36 h. The sixth moved 8 m on land, down a slope, and burrowed under leaves and then entered the water the next day, all within 24 h of release. The hatchlings remained within 20 m of their entrance points into the river, remaining in shallow (2-3 cm) water, and often buried in sand or detritus with only the head exposed. After extreme flooding caused by heavy rains (25-30 cm in 3 days) in early October, the hatchlings were lost. Three detached transmitters were

found, suggesting significant buffeting of the hatchlings.

At the palustrine New Hampshire site, 15 hatchlings (five with and 10 without transmitters) traveled 3-5 m to enter a nearby wetland stream within 4 h of release. Of the four additional hatchlings with transmitters, one burrowed back into the sand of the nest, where it remained for 2 days until dug out by a predator. Two more entered the water within 24 h, and the fourth traveled 5 m, remained under wetland vegetation for one day, burrowed into sand one day, then traveled 20 m to shallow water (8 cm) at the edge of the stream. Six hatchlings were lost after a flood during the first week of October. On 11 October 2005, eight additional hatchlings were located along the stream within 5 m of the nest. Each was fitted with a transmitter on site and then returned to the stream. Of these, one moved 15 m downstream into the flooded wetland within 24 h, two moved 12 and 17 m downstream into the wetland by 16 October 2005. A fourth moved 15 m into the wetland by 2 November 2005. Four hatchlings remained tucked into roots of sedges and silky dogwood in 2-3 cm water along the edge of the wetland stream, 3-5 m from the nest. A fifth had remained in this location since 22 September 2004 (visually located on 2 November 2005). Three hatchlings were relocated in March 2006, and they were all at the locations at which they were last observed in November 2005. One was located on 8 March, 6 cm below the surface and 2.5 m from the nest site, under sedge roots at the edge of the stream in 1°C water. A second was found on 8 March, 6 cm below the surface in 1°C water under leaves at the base of a submerged log in the wetland 15 m from its nest. A third was found on 10 March, 7 cm below the surface in 2°C water under silky dogwood roots at the edge of the stream 2.5 m from its nest. The three hatchlings increased in mass by 12.9 to 19.5% from autumn release to spring capture, but we cannot partition mass gain between possible autumn feeding and potential winter water uptake.

Discussion

Although the transmitters were small, they still were up to ≈10% of the body mass of the hatchlings, and potentially could snag on vegetation during locomotion. While we cannot discount effects on behavior, since the hatchlings within a given group behaved similarly, we do not think that transmitter attachment had a major effect on behavior relative to that of an unfettered hatchling.

On Long Island, the four hatchlings that were recovered from their hibernacula in April all overwintered in spring seeps away from standing water, in contrast to the behavior of the New Hampshire hatchlings, which all moved to shallow water and remained there to overwinter. The four Long Island hatchlings also initially moved to open water from their release in the nest cavity (two from each nest), but they then followed different paths, sometimes including both aquatic and terrestrial movements, before eventually settling into the spring seeps for overwintering, as did the fifth, although we could not find it in April. In the sense that Long Island hibernacula were not under standing water, the hibernacula were terrestrial and differed from those expected by assuming that hatchlings move to aquatic lentic or lotic habitats and overwinter there, as was the case with the New Hampshire hatchlings. However, the Long Island hatchlings were surrounded by a constantly saturated medium that appeared to have an underground flow, so desiccation was not a threat. We do not know the oxygen content of the interstitial water, but assume that it was appreciable or the turtles would have died if they had remained submerged throughout the winter. Reese et al. (2004) found that Snapping Turtle hatchlings will die in 30 days if submerged in anoxic water at 3°C, compared to survival of adults for at least 125 days under similar conditions (Reese at al. 2002). The limited survival of anoxic hatchlings is attributable to their reduced whole-body buffering capacity, and therefore reduced tolerance of the metabolic acidosis that accompanies the accumulation of lactic acid during anaerobiosis. The reduced buffering capacity is due to the reduced relative amount of bone, especially in the shell, of the hatchlings compared to adults, and is a general characteristic of hatchling turtles (Reese et al. 2004). This inability to tolerate anoxia would preclude the turtles from hibernating for extended periods in anoxic conditions, such as mud under standing water. Thus the seep water that surrounded the hatchlings must have had a significant amount of dissolved oxygen, perhaps maintained by a constant percolation of oxygenated spring water that exceeded the biochemical oxygen demand of the detritus at the low wintertime temperatures. Alternatively, it is possible that the hatchlings may have occasionally air-breathed, since the soil surface of the seeps did not freeze during the winter. Air-breathing would require that the animals move to the surface to breathe (on the assumption that the water saturation prevents any underground air pockets from forming); since turtles are not completely immobilized by cold, air-breathing cannot be ruled out. Why the hatchlings moved out of open water to hibernate in the seeps, or how they oriented toward them, is uncertain.

Thus the overwintering habitats of hatchling Snapping Turtles are varied, ranging from the expected shallow-water retreats typical of the New Hampshire hatchlings, to the use of wet but not aquatic sites (e.g., seeps), even though aquatic sites are nearby and easily accessible, as seen with the Long Island hatchlings. The use of seeps as hibernacula for turtles, especially young ones, may be more common than has been appreciated. V. Lamoureaux (personal communication), while studying the use of seeps as hibernacula for Green Frogs (*Rana clamitans*) in New York (Lamoureux and Madison 1999), found one adult and three

juvenile (9.5 – 11 cm) Snapping Turtles leaving a seep area in late April, where they apparently overwintered, and moving toward a nearby pond. Dunson (1986) radiotracked four snapping turtles in a tidal marsh area in Virginia, and they all moved to seep/spring areas on higher ground, which remained unfrozen throughout the winter, suggesting that the use of seeps as hibernacula may not be limited to immature turtles, although almost all reports of hibernacula of adult Snapping Turtles are of those covered by standing or flowing water (Ultsch 2006).

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Notes on Succession in Old Fields in Southeastern Ontario: the Herbs

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Vegetation in abandoned hayfields was monitored during 1976-1998. An earlier successional stage followed ploughing. Changes in tree, shrub and vine populations have been reported earlier and showed expected increases in species richness and cover. Highest species richness of herbs occurred three years after ploughing. Non-woody species richness trended irregularly downward, while non-woody cover was variable, peaking in 1987. Within the herbaceous community, year-to-year changes in cover and frequency of species in the following selected groups are reported here: 18 grasses including sown and adventive species; 13 legumes including two sown species; 14 macroforbs of the *Compositae*, including a goldenrod, *Solidago canadensis,* which dominated parts of the fields; a rosette weed, *Taraxacum officinalis*; sedges, horsetails and some other minor components. Grasses and goldenrods were grazed, sometimes intensively and repeatedly, by insects; grasses were impacted by skipper larvae (*Thymelicus lineola*), and goldenrods by beetle larvae (*Trirhabda* spp.). Effects of repeated outbreaks on host plant cover are shown for two plots (100 m^2) matching the scale of outbreaks.

Key Words: old field herbs, phytophagous insects, plant succession, goldenrods, grasses, legumes, Ontario.

Two abandoned hayfields in southeastern Ontario were selected as sites in which to investigate possible effects of insect herbivory on early stages of secondary succession. The location, geology, history of land use, and soils have been described earlier (Crowder and Harmsen 1998). Their nutrient status was discussed by Epp and Aarssen (1988). Estimates of increasing cover and abundance of trees, shrubs and vines (51 species) during 1976-1998 were shown to follow classic successional models, although with unusual pioneer species. After two decades the structure of the vegetation had become heterogeneous, with groves of small trees, shrub thickets, patches dominated by macroforbs and patches still dominated by grasses. Cover varied with fluctuations of weather from year to year, while soil differences influenced cover and species richness.

Most successional studies on old fields use synoptic records from fields of different ages, a method which obscures minor fluctuations and differences between fields. In this paper, year-to-year observations are used to follow temporal changes in the herbaceous community and to relate its cover and species richness to those of the woody layers. Herbaceous species found in 27 experimental plots are listed to allow comparisons with other areas; lichens and bryophytes are omitted. Differences in soil texture (Crowder and Harmsen 1998) influenced cover and richness.

Within the herbaceous community, details of temporal change in selected groups of plants and some specific interactions are reported here. Grasses were the main constituents of the hayfields, including both agricultural and adventives species. Legumes also included sown and invasive species. Invasive macroforbs, mainly *Solidago* and *Aster* species, dominated parts of the fields; population changes of 15 species are reported. *Taraxacum officinalis*, Dandelion, was selected to represent rosette plants. Sedges, horsetails and a few other minor components are described.

During the decades when vegetation was monitored, arthropods were also sampled (McBrien et al. 1983). Two insect populations had repetitive outbreaks which caused significant decreases of plant cover, and are therefore the only arthropods reported here. Larvae of the hesperiid European Skipper (*Thymelicus lineola*) grazed on grasses, particularly on Timothy, *Phleum pratense* (Henderson 1986). Larvae of beetles of the genus *Trirhabda* Le Conte (Coleoptera, Chrysomelidae), mostly *Trirhabda virgata,* grazed primarily on leaves of *Solidago canadensis*, causing intense defoliation. The strong effect of one or more outbreaks of beetles on plant vigour was replicated experimentally (McBrien and Harmsen 1987). These defoliations can cause changes in successional pathways at the grass-macroforb stage by affecting the relative dominance of grass or goldenrods. Blatt et al. (2001) have used these data to develop a successional model including herbivore effects, showing possible outcomes for the herbs.

Methods

A hayfield abandoned in 1970 and one mown for hay until 1975 were selected at Queen's University Biology Station at Opinicon, Frontenac County, Ontario (44°03'N, 76°0'W). Nine permanent plots, each 100 m^2, were demarcated in 1975 in the older field, which was called S field, for *Solidago*. Eighteen similar

plots were placed in the younger field, and nine of these were ploughed once; these ploughed plots were called P and the undisturbed plots G, for grass. All plant species present in the 27 plots were listed in June and September of sampling years: 1976-1988, 1995, 1998. Cover was estimated using five randomly placed quadrats within each plot; cover values used in this paper were from September (McBrien et al. 1983; Henderson 1986). Each quadrat was 50 cm × 50 cm in area. Values were compared using Scheffe's mean separation test (Zar 1984; Blatt et al. 2003). Percentage frequency, the number of quadrats in which a species was recorded at a particular time (Mellinger 1972; Eriksson and Jakobssen 1998), was used as a measure of relative abundance (Maycock and Guzikowa 1984).

Nomenclature follows Newmaster et al. (1998); voucher specimens were lodged at the Fowler Herbarium, Queen's University. Lichens, mosses and liverworts have been omitted from this paper.

Results and Discussion

Species richness of woody species and of herbs per 100 m^2 plot, through 1976-1998, is shown in Figure 1. Note gaps in sampling after 1988. Herb richness trended downward with high annual variance while woody species richness increased over time (see Crowder and Harmsen 1998).

The range of species richness was 7-65 in ploughed (P) plots, 6-42 in grass-dominated (G) plots, and 6-33 in *Solidago* (S) plots. Species richness of herbs and of woody plants in a grass plot (G1) and a ploughed plot (P2) are shown in Figures 2 and 3. Because soil texture was found to be correlated with species richness, the selected plots were matched for texture; both are sandy, with relatively low richness (Crowder and Harmsen 1998). Note the difference in scale between Figures 2B and 3B. Species richness peaked in P2 three years after ploughing when several weedy species were present (cf. Armesto and Pickett 1985).

Herbaceous taxa observed in 27 plots during 1976-1998 are listed in Table 1, in alphabetical order, with English names added (Newmaster et al. 1998). The closest comparable study site is a 50-year-old field, at Erindale (Toronto area), described by Maycock and Guzikowa (1984), in which 93% of the species listed at Opinicon were found. Other old fields in Ontario have been described by Lamoureux (1970), Reader (1990) and Reader and Buck (1991). Fewer of the Opinicon species (37%) were found in abandoned hayfields in New York State described by Mellinger (1972), and only 20% in old fields in Quebec (Dansereau and Gille 1949). The proportion of introduced species at Opinicon was 37%, which is higher than the average for the Kingston region (Beschel et al. 1970). They included both crop plants and weeds.

During 1976-1998 the cover value of woody plants for all plots combined increased significantly (Crowder and Harmsen 1998); herbaceous cover, however, did not decrease significantly over time (Figure 1). Mean percent cover of non-woody species in 1998 was not significantly different from that in 1988, 1986, 1984, 1978, 1977 and 1976. Years with high cover were 1979, 1980, 1981, 1985, or 1987 (Figure 1). These values suggest that herbaceous cover was related to year-to-year changes in weather or herbivory rather than to a steady increase in shading. No correlations of cover values with available climatic data were found, although the years with low cover had partial droughts that caused soil cracking.

Herb cover in selected plots is shown in Figures 2A and 3A, with relatively low variance between years. Plot G1 consistently had higher values than P2. The main components of herb cover are discussed in the following section. The hayfields had been sown with *Phleum pratense* (Timothy) and *Poa pratensis* (Kentucky Blue Grass), which maintained their frequency after the cessation of mowing (see Table 2). Mellinger (1972) also reported their high frequency in old hayfields in New York. In the Opinicon fields the two species are associated randomly (Epp and Aarssen 1988).

Table 2 lists annual percentage frequency of nine grass species. The most frequent invasive grasses have been *Elymus repens*, *Poa compressa* and *Calamagrostis canadensis*. Other less common invasive grasses, not shown on Table 2, were *Bromus inermis* ssp. *pumpellianus*, *Echinochloa crusgalli*, *Elymus trachycaulon* ssp. *trachycaulon*, *Muhlenbergia mexicana*, *Panicum acuminatum*, *Poa capillare*, *Poa annua*, *Setaria pumila* and *Setaria viridis*. Annual cover of all grass species in all plots varied from a mean of 35% in 1998 to a mean of 87% in 1987. Cover in the G (grass) plots exceeded 100% in some years, because layers of two or more species developed. Differences between the three sets of plots were not consistent.

Cover of grasses did not show synchronous trends within sets of plots. Changes in grass cover were not correlated with soil texture; the two plots shown in Figures 2 and 3 were matched for soil texture but the undisturbed plot G1 in Figure 2 had high grass cover and the ploughed plot in Figure 3 had not. A temporal pattern in the grass-dominated plot showed successive peaks three to five years apart followed by declines in cover values. This pattern was typical of grass-dominated plots. The disturbed ploughed plot shown in Figure 3 had two less marked peaks and declines. Herbivory was demonstrated by Henderson (1986) to reduce grass cover significantly; he counted larvae of a hesperiid European Skipper (*Thymelicus lineola*) and found that peaks of larval numbers coincided with low cover of *Elymus repens*, *Phleum pratense* and *Poa pratensis*, and low concentrations of skipper larvae with high grass cover. The grass species differed in their capacity to recover after an insect outbreak, with *Phleum pratense* being most negatively affected. Outbreak behaviour by the European Skipper has been documented by Pengelly (1961) elsewhere in Ontario.

TABLE 1. Alphabetic list of herbs recorded within 27 plots during 1975-1998 at two old fields at Opinicon, with English names. Nomenclature follows Newmaster et al. (1998).

Acalypha virginica. Copperleaf
Achillea millefolium ssp. *millefolium.* Yarrow
Agrimonia gryposepala. Hooked Agrimony
Agrostis gigantea. Redtop
Ambrosia artemisiifolia. Common Ragweed
Anaphalis margaritacea. Pearly Everlasting
Anemone canadensis. Canada Anemone
Antennaria neglecta. Field Pussytoes
Antennaria parlinii. Plantain-leaved Pussytoes
Arctium minus ssp. *minus.* Common Burdock
Artemisia absinthium. Absinth
Asclepias syriaca. Common Milkweed
Aster cordifolius. Heart-leaved Aster
Aster ericoides. Heath Aster
Aster lanceolatus. Panicled Aster (includes *Aster simplex*)
Aster lateriflorus. Calico Aster
Aster umbellatus. Flat-topped White Aster
Aster urophyllus. Arrow-leaved Aster
Barbarea vulgaris. Wintercress
Bromus inermis ssp. *pumpellianus.* Smooth Brome
Calamagrostis canadensis. Canada Blue Joint
Capsella bursa-pastoris. Shepherd's Purse
Carex aurea. Sedge
Carex communis. Common Sedge
Carex debilis. Sedge
Carex foenea. Sedge
Carex gracillima. Filiform Sedge
Carex granularis. Granular Sedge
Carex laxiflora. Slender Sedge
Carex normalis. Normal Sedge
Carex scoparia. Sedge
Carex vulpinoidea. Fox Sedge
Cerastium fontanum ssp. *triviale.* Common Mouse-ear Chickweed
Chenopodium simplex. Maple-leaved Goosefoot
Chrysanthemum leucanthemum. Ox-eye Daisy
Cichorium intybus. Chicory
Cirsium arvense. Canada Thistle
Clinopodium vulgare. Wild Basil
Convolvulus arvensis. Field Bindweed
Conyza canadensis. Canada Fleabane
Dactylis glomerata. Orchard Grass
Danthonia spicata. Poverty Oat Grass
Daucus carota. Wild Carrot
Dianthus armeria. Deptford Pink
Echinochloa crusgalli. Echinochloa
Echium vulgare. Blueweed
Elymus repens. Couchgrass
Elymus trachycaulus ssp. *trachycaulus.* Slender Wheat Grass
Epilobium hirsutum. Hairy Willow Herb
Equisetum arvense. Field Horsetail
Equisetum hyemale. Scouring Rush
Erigeron annuus. Daisy Fleabane
Erigeron philadelphicus ssp. *philadelphicus.* Common Fleabane
Erigeron strigosus. Lesser Fleabane
Eupatorium maculatum. Joe Pye Weed
Eupatorium perfoliatum. Boneset
Eupatorium rugosum. White Snakeroot
Euthamia graminifolia. Grass-leaved Goldenrod
Fragaria vesca ssp. *americana.* Wood Strawberry
Fragaria virginiana. Wild Strawberry
Galinsoga quadriradiata. Quickweed
Galium obtusum. Wild Madder
Galium trifidum ssp. *trifidum.* Small Bedstraw
Gentiana andrewsii. Bottle Gentian
Geranium bicknellii. Bicknell's Crane's Bill
Geum aleppicum. Yellow Avens
Geum canadense. White Avens
Hieracium aurantiacum. Orange Hawkweed
Hieracium piloselloides. King Devil
Hypericum perforatum. Common St. John's Wort
Juncus dudleyi. Dudley's Rush
Lactuca canadensis. Wild Lettuce
Lepidium campestre. Field Peppergrass
Lithospermum officinale. Gromwell
Lobelia inflata. Indian Tobacco
Lycopus americanus. Cut-leaved Water Horehound
Lycopus uniflorus. Water Horehound
Lysimachia terrestris. Yellow Loosestrife
Medicago lupulina. Black Medick
Medicago sativa ssp. *sativa.* Alfalfa
Medicago sativa ssp. *falcata.* Medick
Melilotus alba. White Sweet Clover
Melilotus officinalis. Yellow Sweet Clover
Mentha arvensis ssp. *borealis.* Wild Mint
Muhlenbergia mexicana. Dropseed
Oenothera perennis. Sundrops
Onoclea sensibilis. Sensitive Fern
Osmunda regalis. Royal Fern
Oxalis stricta. Yellow Wood Sorrel
Panicum acuminatum. Woolly Panic Grass
Panicum capillare. Witch Grass
Panicum depauperatum. Starved Panic Grass
Phleum pratense. Timothy
Physalis heterophylla. Clammy Ground Cherry
Plantago lanceolata. Narrow-leaved Plantain
Plantago major. Common Plantain
Plantago rugelii. Rugel's Plantain
Poa annua. Annual Blue Grass
Poa compressa. Canada Blue Grass
Poa pratensis ssp. *pratensis.* Kentucky Blue Grass
Polygonum convolvulus. Black Bindweed
Polygonum persicaria. Lady's Thumb
Polygonum sagittatum Arrowleaved Tear-Thumb
Potentilla argentea. Silvery Cinquefoil
Potentilla canadensis. Old Field Cinquefoil
Potentilla inclinata. Downy Cinquefoil
Potentilla norvegica. Rough Cinquefoil
Potentilla recta. Erect Cinquefoil
Prunella vulgaris ssp. *vulgaris.* Selfheal
Ranunculus abortivus. Kidney-leaf Buttercup
Ranunculus acris. Field Buttercup
Rudbeckia hirta. Black-eyed Susan
Rumex acetosella ssp. *acetosella.* Sheep Sorrel
Rumex crispus. Curly Dock
Sanicula marilandica. Black Snakeroot
Setaria pumila. Yellow Foxtail
Setaria. viridis. Green Foxtail
Silene vulgaris. Bladder Campion
Sisymbrium officinale. Hedge-Mustard
Sisyrinchium angustifolium. Blue-eyed Grass
Solidago caesia. Blue-stemmed Goldenrod

TABLE 1. *(continued)*

Solidago canadensis. Canada Goldenrod
Solidago gigantea. Tall Goldenrod
Solidago juncea. Early Goldenrod
Solidago nemoralis ssp. *nemoralis*. Gray Goldenrod
Solidago rugosa. Rough-stemmed Goldenrod
Sonchus asper ssp. *asper*. Spiny Sow-thistle
Spiranthes romanzoffiana. Hooded Ladies' Tresses
Stellaria borealis ssp. *borealis*. Northern Stitchwort
Stellaria graminea. Stitchwort
Stellaria media. Chickweed
Taraxacum officinale. Dandelion
Teucrium canadense ssp. *canadense*. Germander
Thlaspi arvense. Field Pennycress
Tragopogon dubius. Goatsbeard
Tragopogon pratensis ssp. *pratensis*. Showy Goatsbeard
Trifolium aureum. Yellow Clover
Trifolium campestre. Smaller Hop Clover
Trifolium hybridum. Alsike Clover
Trifolium pratense. Red Clover
Verbascum thapsus. Common Mullein
Verbena hastata. Blue Vervain
Veronica serpyllifolia ssp. *serpyllifolia*. Thyme-leaved Speedwell
Vicia cracca. Cow Vetch
Vicia sativa ssp. *nigra*. Common Vetch
Vicia tetrasperma. Slender Vetch
Viola sp. Violet

Larval outbreaks are considered to affect the successional pathway in the Opinicon fields in a model developed from our data by Blatt et al. (2001). When insect herbivory on grasses in old fields was studied by Brown et al. (1988), *Elymus repens* was the grass species most affected by Homoptera/Auchenorrhycha; these authors considered that both texture and structure of the successional vegetation were affected by the insects.

The initial seed mix contained *Medicago sativa* ssp. *sativa* (Alfalfa) and possibly *Trifolium pratense* (Red Clover) which have persisted in the fields. *Medicago sativa* frequency was 3-5% in 1976-1980, rose to 12% in 1983 and fell again to 2% in the 1990s. *Trifolium pratense* frequency was 35% in 1976, fell to less than 8% during 1980-1995 and rose again to 22% in 1998. *Trifolium aureum, Trifolium campestre* and *Trifolium hybridum* were recorded occasionally.

Vetches (*Vicia sativa* ssp. *nigra*, *Vicia cracca,* and *Vicia tetrasperma)* became more frequent in later years with a maximal frequency of 69% for *Vicia cracca* in 1987. Possibly these straggling plants benefited from the cessation of mowing. Other legumes recorded were *Melilotus alba, Melilotus officinalis* and *Medicago lupulinus*, randomly distributed except for *Medicago lupulina*, which was most frequent in 1976-1979 in the ploughed plots.

Macroforb areas of the fields have been and are dominated by *Solidago canadensis* (Canada Goldenrod), which we observed to spread by both seeds and rhizomes. Its importance in old field succession in North America has been widely reported (e.g., Dale et al. 1966; Goldberg and Gross 1988). Percentage frequency of *Solidago canadensis* in all plots during 1976-1998 is shown as mean values in Table 2, starting with minimal values in 1976 and reaching a maximum in 1987-1988. Frequencies of *Solidago nemoralis* (Old Field Goldenrod), *Solidago caesia* (Blue-stemmed Goldenrod), and *Euthamia graminifolia* (Grass-leaved Goldenrod), also given in Table 2, were higher in the 1980s than in the 1970s or 1990s. When the three sets of plots were compared, *Solidago canadensis* and *Solidago caesia* were found to be most frequent in the S plots (during 1976-1998 the mean frequency of *Solidago canadensis* in S plots was 47%, in the P plots 37% and in the G plots 26%). *Solidago nemoralis* and *Solidago juncea* were generally more frequent in sandy dry plots. This distribution may be explained by different soil moisture tolerances among the congeners (Werner and Platt 1976).

Cover values for *Solidago canadensis* ranged from 1 to 100%. Patterns were not synchronous between plots. Two examples are shown. Figure 3 shows Plot P2, with three irregular peaks of goldenrod cover, and Figure 2 shows Plot G1 with only three years of sporadic goldenrod cover. The plot with three peaks and lows (Figure 3) had a periodicity also observed in other plots, while others had one, two, or three-and-a-half episodes. Some sandy plots similar to that shown in Figure 2 failed to develop dense *Solidago* cover, and did not have a series of highs and lows.

We have found that the cover of *Solidago canadensis* was negatively and significantly correlated with larval density of three species of *Trirhabda* beetles in the field (McBrien et al. 1983; Blatt et al. 2001). *Trirhabda virgata* was most abundant. Field experiments showed that effects on biomass and cover similar to those caused by larval grazing could be produced by manual defoliation (McBrien and Harmsen 1987).

Within a field, beetle outbreaks were not synchronous between plots. Outbreaks in the two fields also occurred at different times. In the P/G field, years with several plot peaks of *Solidago* cover were 1980, 1981, and 1985, and years with most lows were 1976, 1985 and 1998. That both peaks and lows occurred in 1985 shows the small scale of the beetle outbreaks, sometimes confined to a plot 100 m^2. Outbreaks on a much larger scale have been reported, for example, on a scale of several hectares (Werner et al. 1980), and over two hundred insect species have been reported on *Solidago canadensis*.

Macroforbs growing to the same size as some goldenrods included the asters *Aster umbellatus* (Flat-topped White Aster) and *Aster novae-angliae* (New

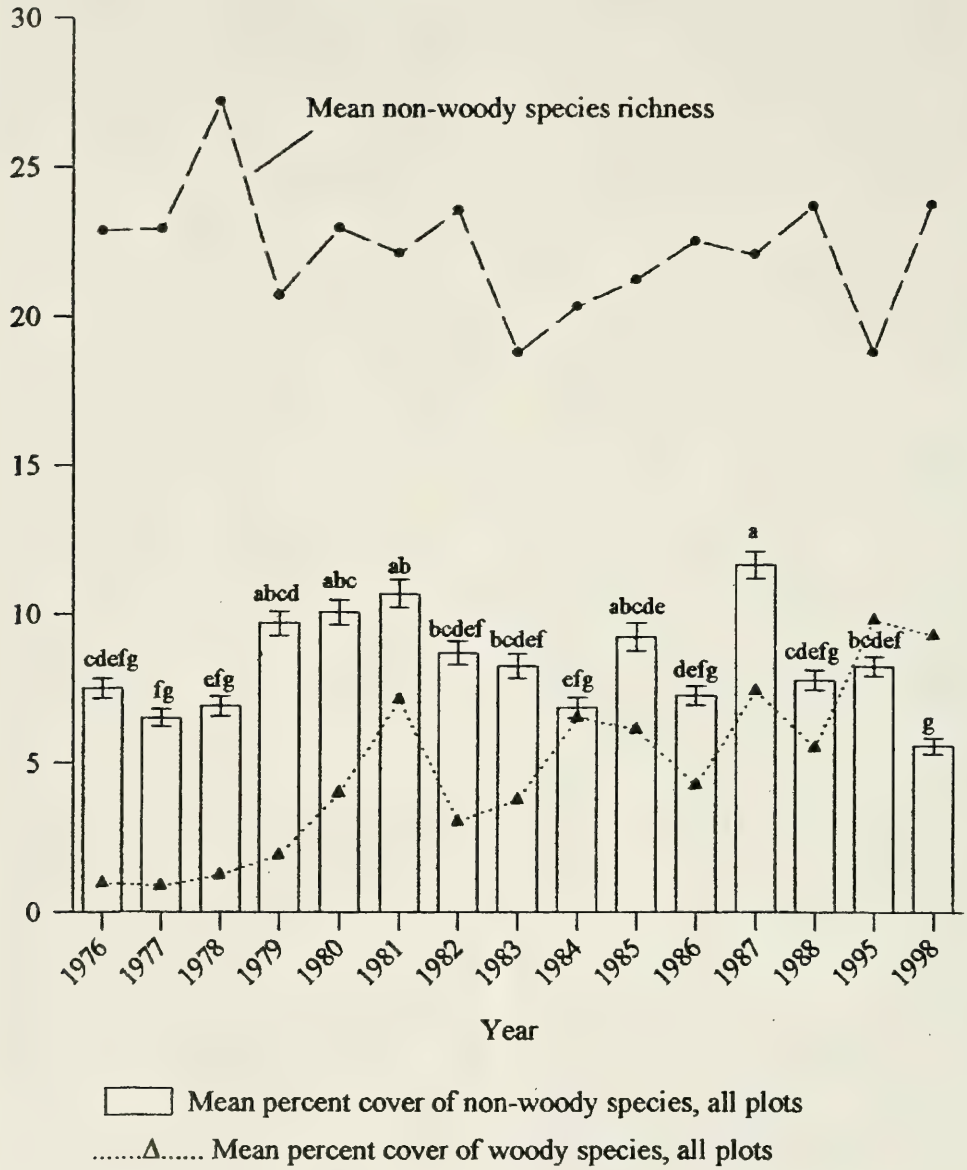

FIGURE 1. Comparison of woody and non-woody vegetation. Mean species richness of herbaceous plants in 27 plots (species number/100 m^2) for the years 1976-1988, 1995 and 1998 is shown by dots. Mean percent cover of non-woody species in all plots in September is shown in the histogram; means which do not share the same letter are significantly different. Mean percent cover of woody species in all plots is indicated by a dotted line with triangles.

England Aster). During the years of observation the percentage frequency of these two species increased (Table 2). Three smaller species, *Aster lanceolatus* (included in *Aster simplex* in Table 2), *Aster lateriflorus* and *Aster ontarionis*, have been lumped together because they were generally intermingled in straggling clumps which also increased in frequency. *Aster cordifolius* (Heart-leaved Aster) and *Aster urophyllus* (Arrow-leaved Aster), both of which are shade-tolerant (Semple et al. 1996), had low frequency. Five of the aster species found in the Opinicon fields were recorded by Maycock and Guzikowa (1984).

When all aster species are lumped together, mean annual cover ranged from 1 to 45%. Comparing dif-

TABLE 2. Mean percentage frequency of selected herbs in all plots during 1976-1988, 1995 and 1998 (n = 162)

Year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1995	1998
Poa pratensis	67	65	52	71	68	57	70	60	40	74	77	76	79	77	68
Phleum pratense	54	40	37	48	46	52	44	19	34	26	30	41	52	37	23
Elymus repens	43	22	37	37	38	25	31	25	33	35	43	49	52	30	22
Poa compressa	0	0	0	0	3	0	0	23	0	<1	<1	6	23	4	3
Calamagrostis canadensis	0	11	2	1	0	3	1	0	1	<1	0	23	29	14	16
Panicum depauperatum	3	6	2	3	0	0	0	0	0	<1	<1	4	1	0	0
Panicum lanuginosum	0	4	4	1	<1	1	2	<1	<1	0	2	0	<1	0	0
Dactylis glomerata	1	<1	1	0	<1	0	<1	0	<1	<1	<1	1	2	0	<1
Agrostis gigantea	0	0	0	0	0	0	0	0	0	0	5	0	<1	0	<1
Solidago canadensis	33	33	40	30	43	45	43	43	38	25	37	49	49	36	39
Solidago nemoralis	6	0	7	6	9	9	10	8	12	9	7	7	8	3	4
Solidago rugosa	2	1	2	4	4	4	6	6	4	9	6	4	4	2	6
Euthamia graminifolia	3	3	4	5	10	12	8	6	7	9	11	12	10	8	8
Solidago gigantea	1	1	0	1	4	2	4	6	6	21	7	3	4	4	6
Solidago caesia	<1	0	<1	0	<1	<1	<1	<1	0	0	0	0	0	<1	<1
Solidago juncea	0	0	0	0	0	<1	0	2	1	7	6	4	6	4	0
Aster umbellatus	2	2	7	2	6	3	7	8	9	9	12	6	11	20	26
Aster novae-angliae	3	1	3	2	3	6	5	3	3	6	6	9	7	7	9
Aster cordifolius & *A. urophyllus*	1	8	7	8	7	8	8	4	3	4	5	5	5	3	4
Aster simplex, A. lateriflorus & *A. ontarionis*	15	19	27	20	21	19	33	27	26	25	39	38	43	33	31
Aster ericoides	0	1	3	0	0	0	0	0	0	0	0	2	0	0	0

ferent plots, patterns of peaks and lows like those observed in *Solidago canadensis* occurred in some plots, but with a longer periodicity ranging up to ten years. Since these fluctuations in cover were not synchronous between plots or fields, it is possible that they were due to herbivory, like the changes in *Solidago* and grasses.

Two species of horsetail, *Equisetum arvense* and *Equisetum hyemale*, were present in the P/G field throughout 1976-1998 with a combined mean percentage frequency of 68%. Both species were most frequent in sandy plots and are locally common in disturbed habitats such as sandpits (Crowder et al. 1997). Cover did not exceed 29% for the two species combined in any year, and was generally low.

Mean frequency of *Taraxacum officinale* ranged from 13% in 1981 to 37% in 1988. Dandelions were present in all three sets of plots every year, with highest frequency in the S and lowest in the G plots. The rosette growth form of *Taraxacum officinale* is similar to that of many genera in the plots, such as *Hieracium* spp. and *Antennaria parlinii*, and probably facilitates early spring growth.

Sedges, *Carex* spp., were observed in all years and in all sets of plots, but were not analysed because of difficulty in distinguishing non-flowering stages. *Carex granularis, Carex laxiflora* and *Carex normalis* were relatively abundant. Mean annual frequency of all species was 39% and most plants were found in plots with high moisture content (Crowder and Harmsen 1998). Mean cover was less than 2% until 1979, rose to 7% in 1987, and then declined again.

Species which increased in both frequency and cover during 1976-1998 included *Asclepias syriaca* (Milkweed) and *Ranunculus acris* (Field Buttercup). Species which declined in both frequency and cover included *Rumex acetosella* ssp. *acetosella* (Sheep's Sorrel), *Ambrosia artemisiifolia* (Ragweed), *Oxalis stricta* (Yellow Wood Sorrel), and *Prunella vulgaris* ssp. *lanceolata* (Self-Heal). *Rumex acetosella* and *Ambrosia artemisiifolia*, which are weedy species, were mostly in the ploughed plots, whereas *Prunella vulgaris* was initially concentrated in grass plots. A minor component with low cover value but high frequency (40-50%) was *Potentilla recta* (Erect Cinquefoil).

When grass cover was lowered by grazing of *Thymelicus lineola*, feeding preferentially on *Phleum pratense*, cover of *Solidago* and *Aster* spp. in both fields increased rapidly; they then maintained their dominance at levels equal to that of *Poa pratensis*, preventing the recovery of *Phleum pratense* (Henderson 1986; Blatt et al. 2001; Blatt et al. 2003). In addition to interactions between grasses and goldenrods, other layers were affected. For example, when the cover of *Solidago canadensis* was decreased by the feeding of beetle larvae a chamaephyte, *Fragaria virginiana* (Wild Strawberry), showed significantly increased cover (McBrien et al. 1983). This finding

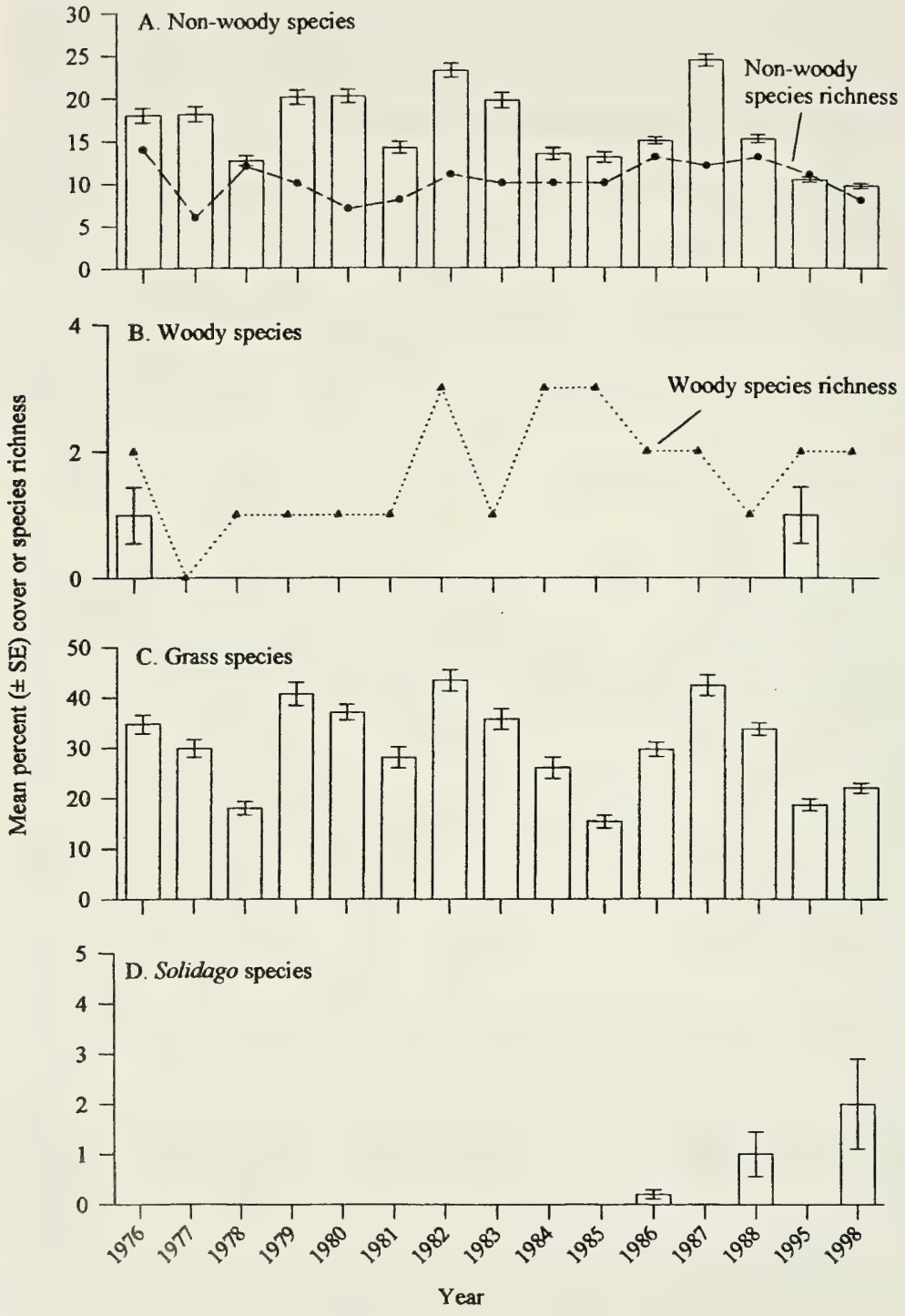

FIGURE 2. Conditions in grass plot G1 during 1976-1988, 1995 and 1998. 2A shows mean percent cover of non-woody species, and non-woody species richness (species number/100 m^2). 2B shows cover and species richness of woody plants. 2C shows mean cover of all grass species. 2D shows *Solidago* species cover, which was only present in 1986, 1988 and 1998.

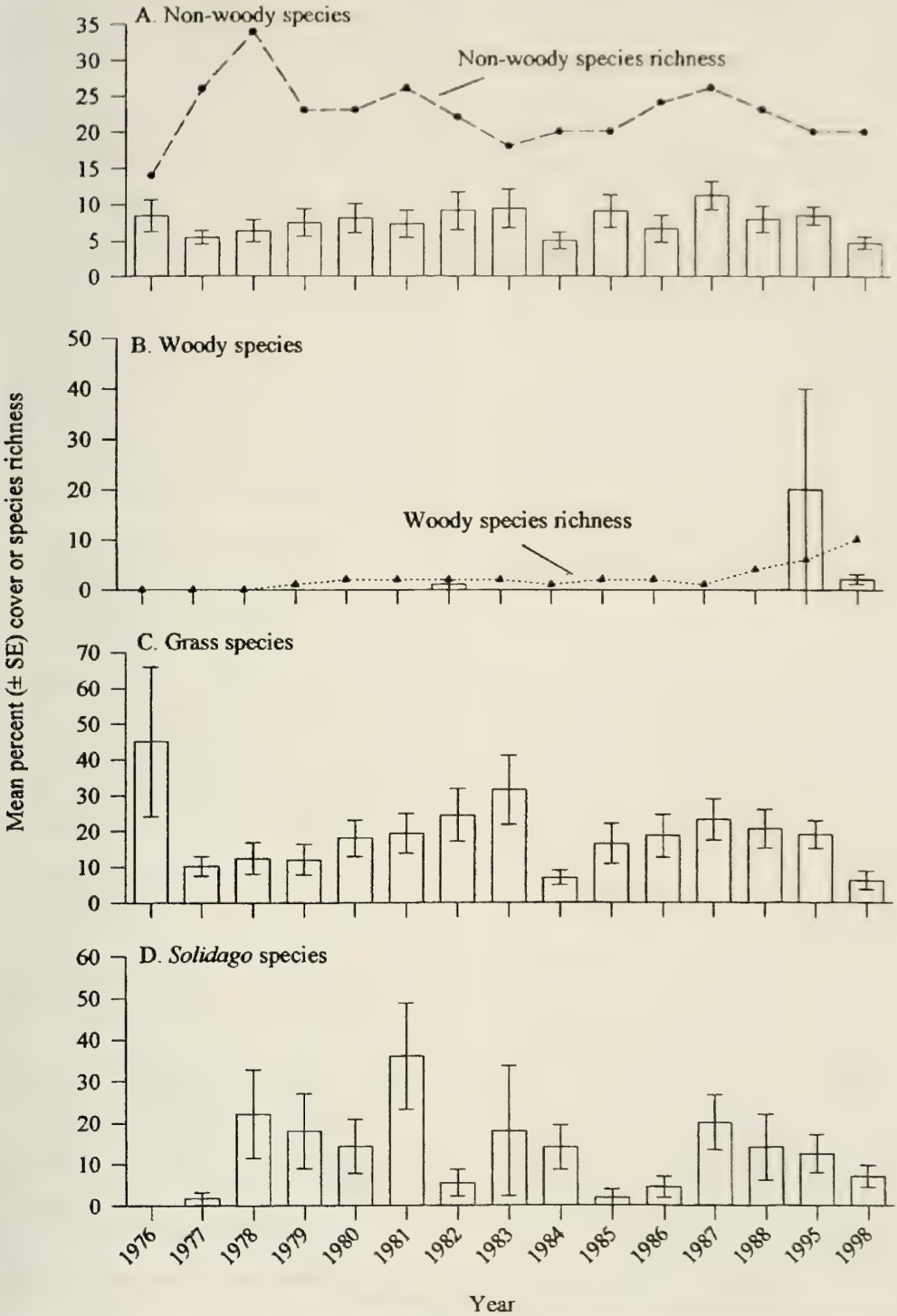

FIGURE 3. Conditions in ploughed plot P2 during 1976-1988, 1995 and 1998. 3A shows non-woody species richness (species/100 m^2) and mean annual percent cover. 3B shows woody species richness and cover. 3C shows cover of all grass species with peaks and lows. 3D shows cover of *Solidago* species with peaks and lows.

has been confirmed elsewhere by Carson and Pickett (1990) who attributed it to decreased shading by the macroforb.

Shade-tolerant herbs in the plots included *Sanicula marilandica* (Black Snakeroot), *Teucrium canadense* ssp. *canadense* (Germander), *Lactuca canadensis* (Wild Lettuce), *Solidago caesia* and *Aster cordifolius*. The increase in woody plants documented by Crowder and Harmsen (1998) could have been expected to create conditions favouring increases of such shade-tolerant species. They did not, however, increase in frequency or cover over time. Presumably shaded microniches under plants such as goldenrods were present in early years and were later replaced by similar conditions under shrubs or trees.

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Growth of White Spruce, *Picea glauca*, Seedlings in Relation to Microenvironmental Conditions in a Forest-Prairie Ecotone of Southwestern Manitoba

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The influence of microenvironmental conditions on the growth performance (i.e., diameter and height growth) of White Spruce [*Picea glauca* (Moench) Voss] seedlings was examined within three contrasting habitats: White Spruce tree islands, open prairies and Trembling Aspen (*Populus tremuloides* Michx.) groves. These habitats exist within a disjunct occurrence of White Spruce at its southern limit of distribution in three mixed-grass prairie preserves in the Spruce Woods Provincial Park within the forest-prairie ecotone of southwestern Manitoba. Microenvironmental measurements (i.e., light, temperature, relative humidity, soil moisture) were obtained on 10 sites in each of the three habitats and growth characteristics of 60 White Spruce seedlings were measured in each of three habitats. Higher light and soil temperature conditions occurred within the open prairie. In contrast, lower light and soil temperature conditions occurred under the tree canopy of aspen groves and the northern aspect of spruce islands, which moderated the effect of the dry regional climate. Height growth did not vary significantly among the three habitats. The greater diameter growth and decreased slenderness of White Spruce seedlings in the open versus the shaded habitats appears to be a result of increased photosynthesis at higher light intensity and may also represent a morphological adaptation to withstand the effect of increased wind exposure. The increased slenderness of White Spruce in the shaded habitats appears to be a morphological adaptation of increasing carbon allocation towards height growth and thus maximizing effective competition for light.

Key Words: White Spruce, *Picea glauca*, prairie-forest boundary, aspen parkland, growth, microenvironment, seed-seedling conflicts, Manitoba.

In the prairie provinces of Canada, the southern limit of conifer species occurs in the aspen parkland. Vegetation in the aspen parkland is dominated by Trembling Aspen (*Populus tremuloides* Michx.) which exists as continuous forest or as groves intermixed with prairie (Bird 1961). The aspen parkland is a transitional vegetation zone (ecotone) between prairie to the south and boreal forest to the north (Bird 1961; Zoltai 1975). The prevailing regional climate of the aspen parkland and mixed-grass prairie in southwestern Manitoba is characterized by low precipitation, high summer temperatures, and dry winds, any of which may be limiting factors to plant distribution and growth (Coupland 1950). For instance, previous studies which examined the radial growth-climate association of White Spruce [*Picea glauca* (Moench) Voss] in the aspen parkland region demonstrated that growth was restricted by moisture deficiency exacerbated by temperature-induced drought stress (Chhin et al. 2004).

Tree invasion into prairies under the dry climate of the aspen parkland must be assisted by favorable microenvironments or "safe sites" (Harper 1977; De Steven 1991a, 1991b; Kellman and Kading 1992; Chhin and Wang 2002). In many prairie environments, shrubs are known to facilitate tree seedling establishment (Callaway 1995; Chambers 2001) by suppressing grass competition (Bird 1961; Werner and Harbeck 1982) and by providing protective conditions from abiotic forces such as fire (Coupland 1950; Bird 1961). The presence of previously established trees in open prairie not only reduces evaporative water loss from plants (Kellman and Kading 1992) but also increases soil moisture and nutrients (Wilson and Kleb 1996; Li and Wilson 1998; Wilson 1998). Furthermore, woody canopies modify the understory microclimate, including shading, interception of precipitation, litter fall (Vetaas 1992), reduced wind speed (Archibold et al. 1996), lower soil temperature, and higher humidity (Carlson and Groot 1997).

Within the aspen parkland of southwestern Manitoba, White Spruce typically establishes under a Trembling Aspen canopy and will eventually replace aspen to form White Spruce forests in the absence of disturbances (Bird 1961). Abundant White Spruce seedlings and saplings are commonly observed in many Trembling Aspen stands, indicating a favorable environment for regeneration. However, White Spruce can occasionally invade open prairies within previously established Creeping Juniper (*Juniperus horizontalis* Moench) patches (Bird 1961; Chhin and Wang 2002). Creeping Juniper is believed to reduce mortality of White Spruce seedlings from prairie ground fires (Bird 1961). The progressive recruitment and establishment of White

Spruce in the open prairie results in the development of White Spruce tree islands which are surrounded by mixed-grass prairie. The islands have an asymmetric spatial structure since White Spruce regeneration is concentrated on the northern aspect of the tree islands. Chhin and Wang (2002) determined that the best environment for White Spruce regeneration within mixed-grass prairie was under the influence of established White Spruce trees (i.e., on the north vs. south aspect and between 4 to 12 m from the spruce island centre, and close association with Creeping Juniper). Other studies have also observed growth of White Spruce in the aspen parkland region on favourable microenvironments such as the north side of trees, north side of river valleys, and other north-facing slopes and microsites (Zoltai 1975; Hogg 1994; Hogg and Schwartz 1997). Together, these previous studies suggested that the suitability for White Spruce establishment decreased from aspen groves (i.e., under a Trembling Aspen canopy), to White Spruce tree islands (i.e., under the influence of established White Spruce trees) and to Creeping Juniper patches in open prairies. However, environmental conditions associated with these habitats have not been documented and how White Spruce growth differs among these habitats has not been quantified.

Ecotones are expected to be sensitive to climatic change, and the environment of the aspen parkland is believed to characterize the future boreal forest under a warmer climate (Hogg 1994). Moderated microenvironmental conditions may potentially serve as microscale refugia or "safe sites" (Harper 1977) for tree seedlings in the context of global warming during the 21st century (IPCC 2007) within a climatically sensitive ecotonal region of the aspen parkland. The first objective of this study was to examine the microenvironmental conditions of five habitats within the aspen parkland of the Spruce Woods Provincial Park (SWPP) in southwestern Manitoba, Canada. These habitats include one habitat in Trembling Aspen groves (AG) [interior (AG-I)], two habitats in White Spruce tree islands (SI) [northern (SI-N) vs. southern (SI-S) aspect], and adjacent to the islands, two habitats in open prairies (OP) [ground vegetation dominated by grass (OP-G) vs. juniper (OP-J)]. The second objective of the study was to compare White Spruce seedling growth (i.e., height and diameter) among three habitats (OP-J, SI-N, and AG-I; seedlings were not sampled in OP-G and SI-S since it was extremely rare to find them in these habitats) and relate growth patterns to the microenvironmental patterns.

Methods

Study area

The study was conducted in the SWPP which is located in southwestern Manitoba (49°40'N, 99°15'W) (Figure 1). The nearest meteorological station with a long-term climatic record is the Brandon Agriculture Station (49°52'N, 99°59'W), which is located about 88.5 km northwest of the SWPP. The area experienced, for the reference period of 1971-2000, an average annual temperature of 2.4°C (Environment Canada 2002). Average annual precipitation amounts to 474.0 mm, with 78.3% as rainfall and the remainder as snowfall. Precipitation peaks in June (75.7 mm), and temperature is highest in July, reaching a daily mean of 18.9°C (Environment Canada 2002). Vegetation in the park is characterized as the aspen-oak grove of the boreal forest region (Rowe 1972). A sandhill, mixed-grass prairie community unique to the aspen parkland is located in the SWPP and consists of Trembling Aspen intermixed with a disjunct population of White Spruce at its southern limit of distribution (Schykulski and Moore 1997). The SWPP resides over an extensive belt of deltaic sands (6500 km^2) created 12 000 years B.P. when a predecessor of the Assiniboine River flowed into glacial Lake Agassiz. The SWPP is located on this delta, and this area has been designated as the Assiniboine Delta Natural Region (ADNR). Within the ADNR, the SWPP contains some of the best examples of the few remaining remnants of native mixed-grass prairie, since most of the native prairie in the ADNR has been lost to agricultural cultivation. The mixed-grass prairie preserves of the SWPP are protected under the mandate of the Prairie Management Plan of Manitoba Conservation in order to preserve its unique and rich biodiversity of plants, insects, and wildlife (Schykulski and Moore 1997).

Natural and anthropogenic disturbances have contributed to the landscape mosaic of the aspen parkland (Bird 1961). In pre-European settlement times, disturbances included fire which occurred naturally or started by Native people in order to maintain the prairie environment for the Bison (*Bison bison* L.). Grazing by herbivores such as Bison and Elk (*Cervus canadensis* Erxl.) prevented the encroachment of the forest onto the prairie. European settlement contributed to the decline of the Bison population due to hunting, livestock grazing, intensive agriculture, and the policy of fire suppression (Bird 1961). The reduction of grazing and fire pressure has resulted in the encroachment of the forest onto the prairie. A policy of fire suppression continues within the SWPP, with intermittent prescribed burning permitted within the mixed-grass prairie preserves (Schykulski and Moore 1997).

Site selection

The study was located in three mixed-grass prairie preserves north of the Assiniboine river: Picnic, Aspen Bluff, and Jackfish prairie (Figure 1). Ten White Spruce islands (SI) with adjacent open prairie (OP), and ten aspen groves (AG) were selected using aerial photographs and field reconnaissance. Four sites of each habitat were chosen in Picnic prairie and Aspen Bluff prairie, whereas two sites of each habitat were selected in Jackfish prairie. Although the occurrence of habitat types could be confounded with environmental con-

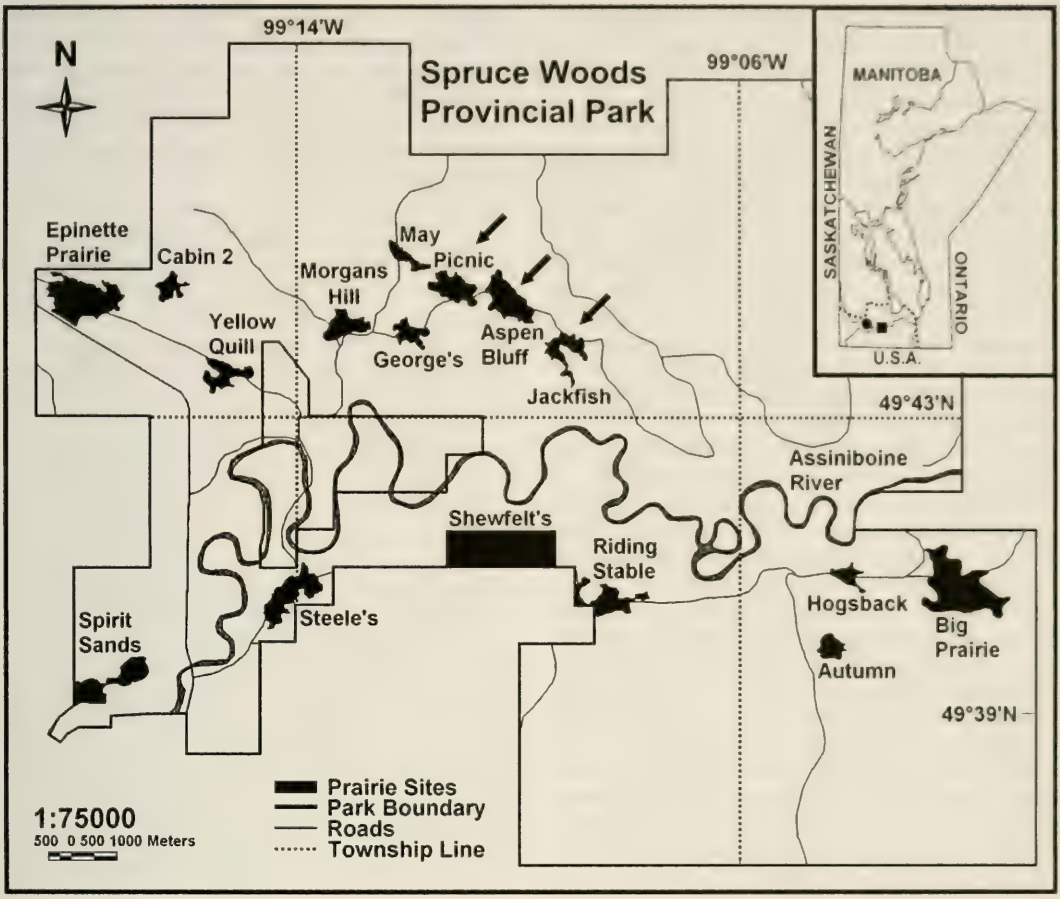

FIGURE 1. Regional setting of the Spruce Woods Provincial Park (SWPP) (■) and the city of Brandon (●) in southwestern Manitoba shown in the inset map. The southern continuous limit of White Spruce according to Farrar (1995) is indicated by the dashed line. The arrows in the enlarged map of the SWPP indicate the mixed-grass prairie preserves in which the study was conducted. Adapted from Schykulski and Moore (1997).

ditions not sampled, the study area is comprised of homogeneous soil conditions which minimize the degree of confounding (Schykulski and Moore 1997). The soil is uniformly sandy and nutrient poor with a poorly developed thin organic layer. Furthermore, it was ensured that sites selected occurred on uniformally flat topography. Additional criteria for spruce island selection were that islands be at least 20 m apart from each other or from the forest edge. Open prairie containing patches of grass and Creeping Juniper were selected adjacent to but at least 20 m away from a spruce island or forest edge. Aspen groves containing understory development of juvenile White Spruce were selected.

Sampling design

The sampling design in a White Spruce island consisted of extending a 12 m transect line on each of the north and south side of a reference tree (i.e., the largest dominant tree of the spruce island). One habitat was selected on the northern (SI-N) and one on the southern (SI-S) aspect of each spruce island. Each SI-N and SI-S habitat was represented by three circular plots (one-meter radius). The centres of the three plots corresponding to each of the SI-N and SI-S habitat were placed 4, 8, and 12 m from the reference tree. Two habitats, a grass habitat (OP-G) and a juniper habitat (OP-J), were selected in open prairie adjacent to White Spruce islands. Each OP-G and OP-J habitat was represented by three randomly placed circular plots (one-meter radius). One habitat was selected in the interior of each Trembling Aspen grove (AG-I) such that there was at least a ten meter buffer zone to the aspen stand edge. The AG-I habitat was represented by six randomly placed circular plots (one-meter radius). Two different habitats were sampled in spruce islands and open prairies because previous studies clearly indicated differences in the establishment of White Spruce seedlings (Chhin and Wang 2002). OP-G generally had no seedling establishment while OP-J occa-

sionally supported seedlings. Many more seedlings were found in SI-N (0.22 seedlings m^{-2}) compared to SI-S (0.008 seedlings m^{-2}).

Data collection

Microenvironment

Solar radiation was measured in the morning (10:00 – 12:00 h) and afternoon (14:00 – 16:00 h) with an AccuPAR Ceptometer (Decagon Devices, Pullman, USA). Measurements for these two periods were averaged. Light measurements were taken at a height of 1.3 m from the north, east, south and west sides of each circular plot. Light intensity of each circular plot was expressed as an average of these four measurements. Light intensities in spruce islands and aspen groves were expressed as percentages of the average light intensity of the open prairie.

Air temperature and relative air humidity (15 cm above ground) were measured using digital thermohygrometers (sensor size: 1 cm diameter) (Barnant, Barrington, USA). Soil (15 cm below the surface) temperature was measured with a thermocouple penetration probe (sensor size: 0.5 cm diameter) and surface temperature was measured with a thermocouple surface probe (sensor size: 1.25 cm diameter) (Barnant, Barrington, USA). These measurements were taken in the centre of each plot and were measured once between 10:00 and 16:00 h.

Surface soil moisture was measured at the centre of each plot with a digital Theta probe soil moisture sensor (Delta-T Devices, Cambridge, UK). The prongs of the Theta probe have a length of 6 cm and thus measure soil moisture of the mineral soil within the top 6 cm. A profile probe was used to measure soil moisture of the mineral soil within the top 40 cm with sensors positioned at the depths of 10, 20, 30 and 40 cm below the soil surface (Delta-T Devices, Cambridge, UK). The profile measurements were taken in an augered hole near the centre of each plot. Due to the limitations in time and instrumentation, not all plots of each habitat could be sampled. Thus, in spruce islands, profile measurements were taken in a single plot 8 m from the reference tree in each of the SI-N and SI-S habitat. One plot of each juniper habitat and one plot of each grass habitat were randomly selected for measurements in each open prairie site. Two plots of the aspen grove interior habitat were randomly selected from each aspen grove. Three profile readings were taken at each plot by rotating the profile probe 120° after each individual reading (Delta-T Devices, Cambridge, UK). The profile measurements of each plot were expressed as an average of these three measurements. Surface and profile moisture measurements were taken between 10:00 and 16:00 h.

All microenvironmental variables were measured on sunny clear days at least 24 hours after any rainfall. These conditions ensured that the habitats were contrasted as much as possible. Profile soil moisture was measured on 4 June 2002. Temperature (soil, surface and air), relative air humidity and surface soil moisture were measured on 5 June 2002. Light intensity was measured on 8 July 2002. The midsummer months of June and July represent typical growing season conditions, and previous studies indicated that precipitation and mean and maximum temperature in the months of June and July strongly affected White Spruce growth (Chhin et al. 2004).

Seedling growth

Six seedlings (< 2 m tall) were destructively sampled from each of the same 10 spruce islands and 10 aspen groves used to collect the microenvironmental data. For each of the three circular plots in the northern aspect (i.e., SI-N habitat) of spruce islands, two seedlings which were nearest to the centre of a circular plot were selected for sampling. Similarly, for each of the six circular plots within aspen groves, one seedling nearest to the centre of a circular plot was selected for sampling. As the open prairie sites used to collect the microenvironmental data did not contain sufficient recruitment of White Spruce, each of the three prairie preserves was surveyed and a total of ten sampling locations were selected which contained greater than six seedlings clustered within a circular area of 10 m radius. Four sampling locations were chosen in Picnic prairie and Aspen Bluff prairie, whereas two sampling locations were selected in Jackfish prairie. The sampling locations were also at least 20 m from the forest edge, White Spruce tree islands or Trembling Aspen groves. At each sampling location within the prairie preserves, the seedling nearest to six randomly chosen points was selected for sampling. All seedlings collected in spruce islands and open prairies were growing within juniper patches.

Height and root collar diameter (RCD) were recorded for each seedling. A section was taken from the root collar of each destructively sampled seedling. Each root collar section was prepared following standard dendrochronological techniques (Yamaguchi 1991; Stokes and Smiley 1996). That is, all wood samples were sanded with progressively finer grades of sandpaper to highlight ring-width patterns. All root collar sections were crossdated under a binocular microscope to ensure accuracy of age determination.

Data analysis

Microenvironment

The Theta probe and profile probe measures the volumetric soil moisture content (θ) which is the ratio between the volume of water present and the total volume of the soil sample. For the Theta probe measurements, units of soil moisture in θ are proportional to voltage (V) via the following linear relationship (Delta-T Devices, Cambridge, UK):

$$[1] \qquad \theta = \frac{[1.1 + 4.44V] - a_0}{a_1}$$

where a_0 and a_1 represent constants which characterize different soil types. Based on a large number of soil samples, generalized values of the parameters

are $a_0 = 1.6$ and $a_1 = 8.4$ for mineral soils (Delta-T Devices, Cambridge, UK); the value of these constants was used in converting the soil moisture of the mineral surface layer from units in V to θ. Similarly, for the profile probe measurements, the following linear relationship was used to convert the soil moisture of the mineral soil at the depths of 10, 20, 30 and 40 cm below the soil surface from units in V to θ (Delta-T Devices, Cambridge, UK):

$$[2] \qquad \theta = \frac{[0.67 + 10.8V] - a_0}{a_1}$$

where the generalized constants for mineral soils are $a_0 = 1.6$ and $a_1 = 8.4$ (Delta-T Devices, Cambridge, UK). Volumetric moisture content is a dimensionless parameter expressed as a percentage (% vol) or as a ratio ($m^3\ m^{-3}$). Equations 1 ($\theta < 50$ % vol) and 2 ($\theta < 30$% vol) are suitable to convert moisture readings in V to % vol for soils of low moisture content, which was the case in this study.

For the subsequent statistical analyses, the microenvironmental variables measured in habitats represented by more than one plot were treated as subsamples and were averaged. Except for the temperature data, all microenvironmental parameters with percentage data were log-transformed (LOG_{10} X). Those variables with zero values were log-transformed using: LOG_{10} (X+1). Analysis of variance (ANOVA) followed by Tukey's multiple comparisons (Wilkinson 1990) was conducted on the light data to compare light conditions among the five habitats (SI-N, SI-S, OP-G, OP-J and AG-I) with ten replicates for each habitat. Similarly, ANOVA was conducted on surface, soil and air temperature; relative humidity; surface moisture; and average moisture of all profile depths in order to compare these parameters among the five habitats. For the log-transformed data, the mean values of the microenvironmental variables for each habitat and the lower and upper limits of a 95% confidence interval were back-transformed by taking antilogs (10^X or $10^X - 1$) so that all means and confidence limits could be reported on their original scale of measurement.

Seedling growth

The height/age ratio (i.e., mean annual height growth), RCD/age ratio (i.e., mean annual diameter growth) and height/RCD ratio (i.e., slenderness coefficient) was determined for all seedlings. The six seedlings per site were treated as subsamples and were averaged for each of the ratios. All of the ratios were compared between habitats via ANOVA with 10 replicates for each of the three habitats.

Results

Microenvironment

Light intensity in White Spruce islands was lower in the northern (SI-N, 54.5%) versus southern (SI-S, 79.1%) aspect ($P < 0.05$) (Table 1). Light intensity in the southern island aspect in turn was not significantly different from the open prairie conditions (OP-G and OP-J) (all $P > 0.05$). Light intensity in the aspen grove interior (AG-I, 18.3%) was significantly less than any of the other habitats (all $P < 0.05$).

Soil temperature differed among some of the habitats (Table 1). Soil temperature within spruce islands was lower in the northern (SI-N, 13.5°C) versus southern (SI-S, 16.4°C) aspect ($P < 0.05$). The spruce island habitats (SI-N, SI-S) in turn were not significantly different from soil temperature in the open prairie grass habitat (OP-G, 15.7°C) (all $P > 0.05$). Both the SI-S and the OP-G habitats had significantly greater soil temperature than the open prairie juniper habitat (OP-J, 13.4°C) (all $P < 0.05$). Soil temperature of the aspen grove habitat (AG-I, 10.2°C) was lower than any of the other habitats (all $P < 0.05$). While surface and air temperature did not differ significantly among the habitats they followed similar relative patterns among the habitats as described for soil temperature.

Although relative air humidity was greatest in aspen groves (AG-I, 36.7%), lowest in the open prairie (OP-G, 30.4%; OP-J, 31.8%), and intermediate in spruce islands (SI-N, 32.7%; SI-S, 33.7%) there were no significant differences in relative air humidity among these habitats (all $P > 0.05$) (Table 1).

Surface soil moisture in the northern island aspect (SI-N, 7.1%) was not significantly different from that in the southern aspect (SI-S, 4.7%) ($P > 0.05$) (Table 1). Soil moisture in the southern island aspect in turn was significantly less than in either the open prairie grass (OP-G, 10.9%) or aspen grove (AG-I, 8.9%) (all $P < 0.05$). Surface soil moisture of the open prairie juniper (OP-J, 8.8%) habitat was not significantly different from the other habitats (all $P > 0.05$). Average soil moisture of all profile depths in the SI-S (1.8%) habitat was less than that in the AG-I (8.0%) habitat (all $P < 0.05$) (Table 1).

Seedling growth

White Spruce seedlings in the open prairie and spruce islands established exclusively amongst Creeping Juniper. Seedlings in aspen groves established exclusively on forest floor litter (i.e., Trembling Aspen leaves). General seedling attributes are shown in Table 2. Mean annual height growth of seedlings did not differ significantly among the three habitats (all $P > 0.05$) (Figure 2). Mean annual diameter growth differed significantly amongst the three habitats (all $P < 0.05$) (Figure 3). Open prairie seedlings had the greatest diameter followed by seedlings from spruce islands and then aspen groves. The slenderness coefficient also differed significantly amongst the three habitats (all $P < 0.05$) (Figure 4). Aspen grove seedlings were most slender, followed by seedlings from spruce islands and then open prairies.

Discussion

Less exposure to solar radiation was expected under the canopy of aspen groves and spruce islands because of shading. Light conditions under aspen canopy

TABLE 1. Microenvironmental conditions of Trembling Aspen groves [interior (AG-I) habitat], and White Spruce tree islands [north (SI-N) and south (SI-S) aspect habitat] with adjacent open prairies [grass (OP-G) and juniper (OP-J) habitat]. The lower and upper limits of a 95% confidence interval of the mean of ten replicates per habitat are shown in parentheses. For each microenvironmental variable, habitats with different letters are significantly different ($P < 0.05$). Except for the temperature data, comparisons were made based on log-transformed data. Microenvironmental variables with no letters for each habitat were not significantly different ($P > 0.05$).

Variable[1]	Habitat OP-G	OP-J	SI-S	SI-N	AG-I
Light (% PAR)	100.0 c	100.0 c	79.1 c	54.5 b	18.3 a
Temp. (°C)	(100.0, 100.0)	(100.0, 100.0)	(62.6, 100.0)	(44.1, 67.2)	(15.9, 21.1)
Soil	15.7 de	13.4 bc	16.4 e	13.5 cd	10.2 a
	(14.1, 17.3)	(11.8, 14.9)	(15.7, 17.1)	(12.1, 14.9)	(9.7, 10.7)
Surface	31.3	30.8	30.1	29.1	28.0
	(28.1, 34.5)	(27.9, 33.8)	(27.3, 32.9)	(27.4, 30.7)	(25.6, 30.3)
Air	31.7	31.6	29.3	30.5	29.1
	(28.7, 34.6)	(28.7, 34.4)	(26.8, 31.9)	(28.9, 32.1)	(26.7, 31.6)
RH (%)	30.4	31.8	33.7	32.7	36.7
	(25.0, 37.1)	(26.0, 38.8)	(26.7, 42.6)	(28.0, 38.1)	(30.5, 44.1)
SM (% vol)					
Surface	10.9 b	8.8 ab	4.7 a	7.1 ab	8.9 b
	(8.7, 13.6)	(6.5, 11.9)	(2.6, 8.5)	(5.1, 9.7)	(7.4, 10.8)
Profile	5.3 ab	2.4 ab	1.8 a	2.0 ab	8.0 b
	(2.0, 12.0)	(0.4, 7.2)	(0.4, 4.5)	(0.7, 4.4)	(6.2, 10.1)

[1]PAR, photosynthetically active radiation; Temp., temperature; RH, relative air humidity; SM, soil moisture

TABLE 2. Attributes of White Spruce seedlings from White Spruce tree islands, open prairies, and Trembling Aspen groves. Standard error of the mean in parentheses.

Attribute	Open Prairie	Spruce Island	Aspen Grove
Sample size (n)	60	60	60
Height (cm)	50.4 (4.9)	49.8 (4.6)	69.6 (6.7)
Diameter (cm)	1.66 (0.21)	1.24 (0.13)	1.16 (0.12)
Age (year)	11.4 (0.6)	11.9 (0.7)	15.1 (0.8)

(18.3%) occurred at levels similar to other studies of aspen stands (Archibold et al. 1996: 23%; Carlson and Groot 1997: 18%). The dominant overstory White Spruce trees cast shade onto the understory, with more shade on the northern versus southern aspect. The reduced soil temperature of the northern versus southern island aspect as well as the lowest soil temperature in aspen groves indicated that areas with increased shade were also cooler. This was expected since temperature is generally a function of solar radiation (Archibold et al. 1996; Morecroft et al. 1998). Decreased soil temperature may lead to decreased evapotranspirative demands in the aforementioned shaded areas. In our study, soil temperature in aspen groves was 3.2-5.5°C less than in the open prairie. Other studies have also reported similar levels of reduced soil temperature in aspen (Archibold et al. 1996: 5°C) and other deciduous stands (Morecroft et al. 1998; 2.5°C) compared to adjacent open conditions. Reduced solar radiation has the potential to moderate the microclimate in forest/grassland ecosystems and thus provide a less hostile environment for tree regeneration and growth (Zoltai 1975; Hogg 1994; Breshears et al. 1997; Hogg and Schwartz 1997).

While light and soil temperature varied significantly among different habitats, surface and air temperature as well as relative air humidity did not. Morecroft et al. (1998) also found that a deciduous forest canopy had a greater effect on reducing soil temperature than air temperature. Although air temperature and humidity did not differ significantly among the habitats, the lower level of air temperature in aspen groves (2.5-2.6°C lower) versus the open prairie was comparable to that observed in other aspen (Archibold et al. 1996: 1.5°C lower; Carlson and Groot 1997: 0.7°C) and deciduous stands (Morecroft et al. 1998: 0.6-0.9°C). Relative humidity was 4.9-6.3% higher in aspen groves compared to the open prairie. This is comparable to a study in the aspen parkland of Saskatchewan by Archibold et al. (1996). They observed that average relative humidity in the summer was generally 4% higher inside than outside an aspen grove. Higher air humidity

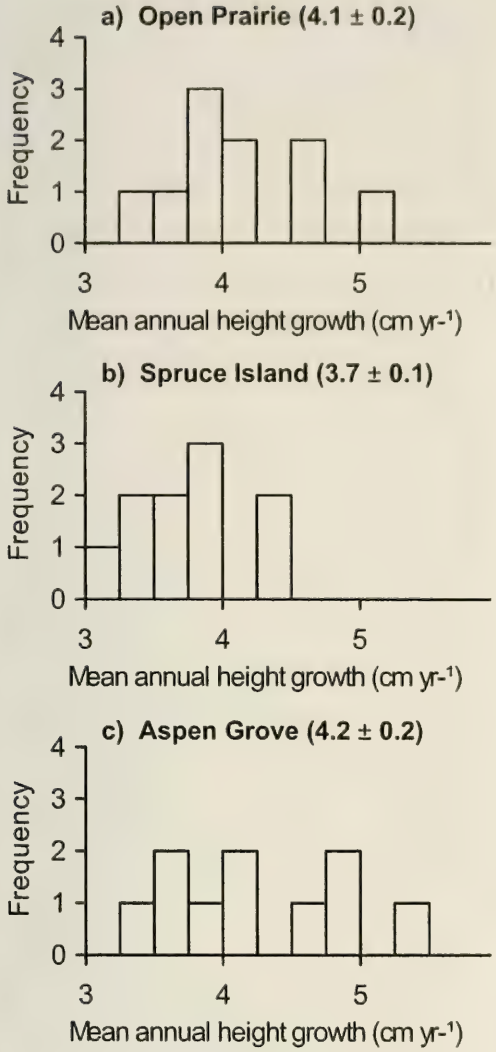

FIGURE 2. Frequency histogram of height/age ratio (i.e., mean annual height growth) of White Spruce seedlings from open prairies (a), White Spruce tree islands (b), and Trembling Aspen groves (c). Mean ± 1 standard error of the mean of 10 replicates per habitat shown in parentheses. Mean annual height growth did not differ significantly among habitats ($P > 0.05$).

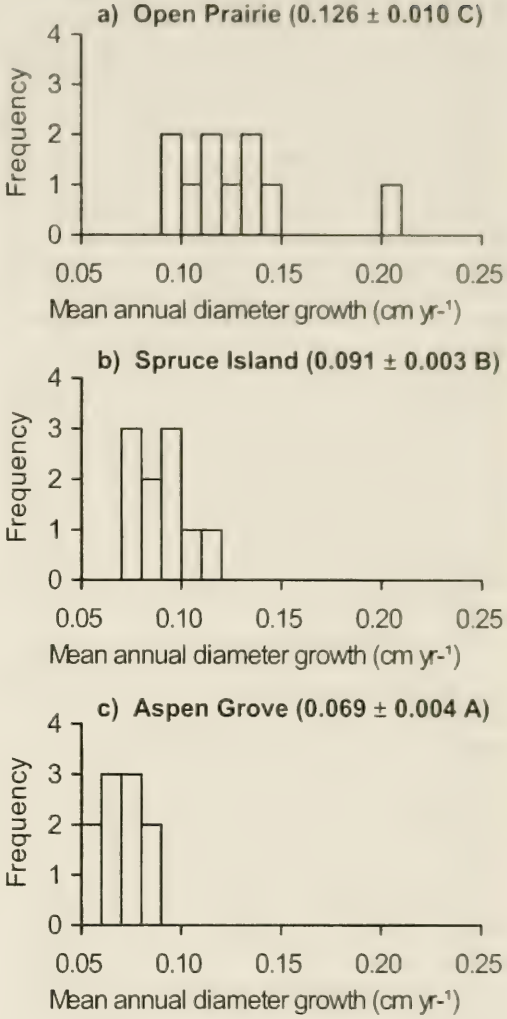
a) Open Prairie (0.126 ± 0.010 C)
b) Spruce Island (0.091 ± 0.003 B)
c) Aspen Grove (0.069 ± 0.004 A)
Frequency
Mean annual diameter growth (cm yr-1)

FIGURE 3. Frequency histogram of RCD/age ratio (i.e., mean annual radial growth) of White Spruce seedlings from open prairies (a), White Spruce tree islands (b), and Trembling Aspen groves (c). Mean ± 1 standard error of the mean of 10 replicates per habitat shown in parentheses, and habitats with different capital letters are significantly different ($P < 0.05$).

is usually linked to the effects of reduced wind speed and reduced air temperature (Archibold et al. 1996)

Some significant differences in soil moisture were observed among the five habitats. Better moisture retention due to increased shading may explain significantly higher surface and profile soil moisture in aspen groves when compared to SI-S. Due to different degrees of shading, both soil surface and profile moisture were also slightly higher on the northern versus southern aspect of spruce islands. These results support the hypothesis of soil moisture retention which asserts that soil moisture is expected to be greater in areas of increased shading (Wilson and Kleb 1996; Li and Wilson 1998; Wilson 1998). The significantly higher soil surface moisture found in OP-G, and the lack of significant difference between open prairies and spruce islands or aspen groves in soil profile moisture are, however, difficult to explain. A possible explanation is that tree or shrub canopies, especially those of conifers, intercept rainfall and thus limit the amount of through-

fall (Vetaas 1992). Although water may also enter soil via stemflow, it has been shown that such water is more likely to infiltrate to deep soil layers to be used by tree species (Parker 1983; Vetaas 1992; Breshears et al. 1997).

Although open prairies represent the worst habitat for White Spruce establishment (Chhin and Wang 2002), they support the best seedling growth. These results support the hypothesis of seed-seedling conflicts which asserts that the habitat requirements for optimal seedling establishment are discordant with that for seedling growth (Schupp 1995). White Spruce did not show any significant differences in height growth amongst the three habitats. In contrast, White Spruce significantly had the greatest diameter growth within the open prairie followed by tree islands and then aspen groves. These results suggest that diameter growth was more responsive to the environmental factors associated with each habitat than height growth. These results are consistent with that of Groot (1999) who reported that diameter growth of young, planted White Spruce was primarily influenced by light availability, whereas height growth exhibited complex relationships with multiple environmental factors.

The larger diameter growth of White Spruce seedlings in the open prairie was not expected given the harsher abiotic microenvironment (i.e., heat stress) of the open prairie compared to the moderated microclimatic conditions within the spruce islands and aspen groves. There are a number of factors which may have contributed to the better diameter growth of seedlings in the open prairie and the lower than expected diameter growth within spruce islands and aspen groves. These factors include the effect of substrate growth conditions, light availability, and morphological adaptations to wind. First, surveying White Spruce seedlings in the open prairie was difficult given the rarity of finding open prairie spruce. Furthermore, those White Spruce individuals that were found grew exclusively in association with Creeping Juniper. Therefore, the better than expected growth in the open prairie may be due to the moderating influence of a Creeping Juniper substrate, and Creeping Juniper is likely providing White Spruce seedlings protective cover from prairie ground fires (Bird 1961). However, seedlings on the northern aspect of spruce islands also established exclusively on juniper. If substrate was a dominant factor influencing diameter growth it is unclear why seedlings from the open prairie and spruce islands would have different diameter growth rates given the same growth substrate.

Corresponding to the diameter growth reduction from OP-J to SI-N to AG-I, the degree of shade increased. The reduced supply of solar radiation could have outweighed the benefits of a moderated microclimate. In other words, while shade is an important moderating microclimatic factor that is conducive to successful White Spruce establishment (Chhin and Wang 2002), shade becomes a limiting factor to subsequent seedling growth. Although ecophysiological

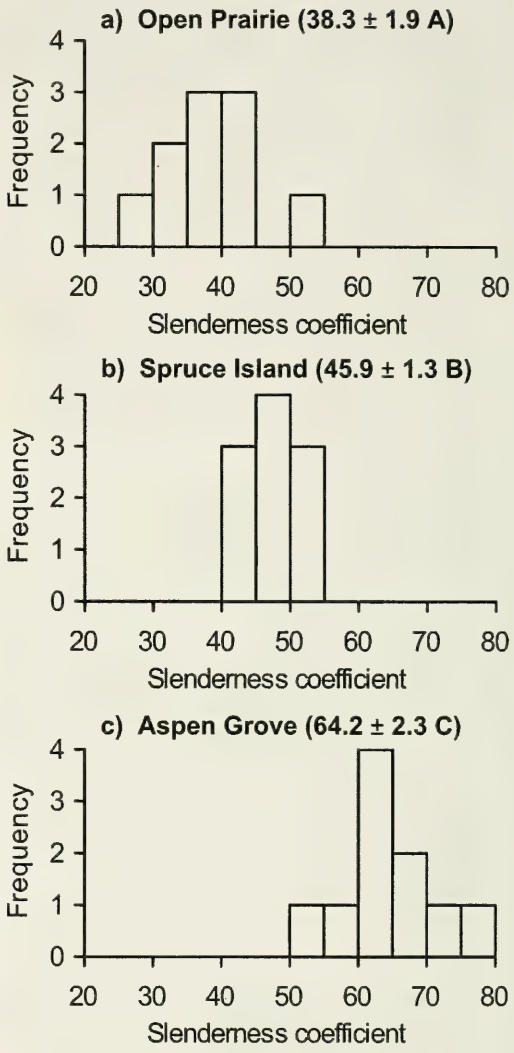

FIGURE 4. Frequency histogram of height/RCD ratio (i.e., slenderness coefficient) of White Spruce seedlings from White Spruce tree islands (a), open prairies (b), and Trembling Aspen groves (c). Mean ± 1 standard error of the mean of 10 replicates per habitat shown in parentheses, and habitats with different capital letters are significantly different ($P < 0.05$).

studies indicate that White Spruce seedlings generally attain maximal height growth at 40% full sunlight (Lieffers and Stadt 1994; Lieffers et al. 1996), seedling diameter growth is greatest at full light intensity (Logan 1969). This may explain the reduced diameter growth of seedlings from the northern aspect of spruce islands which was characterized by light levels of 54.5% of full sunlight. Light levels below 8% generally results in mortality of White Spruce (Lieffers and Stadt 1994). While light conditions under the aspen canopy (18.3%) were greater than this minimal light level, they are

well below that required for maximal diameter growth. Man and Lieffers (1997) also confirmed that light intensity under an aspen canopy was not sufficient to reach the saturation point although light levels were above the compensation point for White Spruce photosynthesis.

Another likely factor which may explain the discrepancy in diameter growth between the three habitats may be morphological adaptations to the effect of wind. Although wind speed was not examined here, it has been shown in another study in Saskatchewan that wind speed in an aspen grove was reduced to 7% of that in adjacent prairie (Archibold et al. 1996). Forest openings are generally characterized by greater wind speeds than forest interiors (Carlson and Groot 1997). Wind causes trees to sway and this can lead to morphological adaptations to resist the effect of wind via increased diameter growth particularly at the base of trees (Kozlowski et al. 1991; Telewski 1995).

The effect of shade and wind is further supported by White Spruce being most slender in aspen groves than in tree islands and the open prairie. These results confirmed our morphological observations in the field. White Spruce seedlings from aspen groves were generally tall and thin, while seedlings from the open prairie were short and thick. White Spruce seedlings from spruce islands were intermediate along this morphological continuum. The morphology of White Spruce under aspen canopy is thus suited for concentrating growth in height to counter the effects of overtopping vegetation (Lieffers and Stadt 1994; Lieffers et al. 1996). The morphology of White Spruce in the open prairie is suited for a more robust stature to withstand the effect of winds during summer (Archibold et al. 1996) and wind and snow abrasion during winter. Wind and snow abrasion have been shown to influence the growth form of open grown spruce at its northern limit of distribution at the tree-line in Churchill, Manitoba (Scott et al. 1993).

The possible discordance in habitat requirements of different developmental stages of White Spruce seedlings may potentially influence successional dynamics in a forest-prairie ecotone in the Spruce Woods Provincial Park. For instance, projecting the initial slow degree of White Spruce seedling establishment in the open prairie onto all developmental stages of White Spruce may underestimate the rate of successional expansion of forest onto prairie, since subsequent seedling diameter growth in the open prairie appears to benefit from high light availability. Nonetheless, further research is required to separate the relative effects of high light availability and increased wind exposure on increased diameter growth of White Spruce seedlings in the open prairie. Projecting the initial establishment success of White Spruce under a Trembling Aspen canopy onto all developmental stages of White Spruce may overestimate the rate of successional replacement of Trembling Aspen by White Spruce, since shade appears to outweigh the benefits of a moderated microclimate for diameter growth of White Spruce seedlings under a Trembling Aspen canopy.

In conclusion, higher light and soil temperature conditions occurred within the open versus shaded habitats. The greater diameter growth and decreased slenderness of White Spruce seedlings in the open versus shaded habitats appears to be a result of increased photosynthesis at higher light intensity and may also represent a morphological adaptation to withstand the effect of increased wind exposure. The increased slenderness of White Spruce in the shaded habitats appears to be a morphological adaptation of increasing carbon allocation towards height growth and thus maximizing effective competition for light. While shade is an important moderating microclimatic factor that is conducive to successful White Spruce establishment (Chhin and Wang 2002), our study has shown that at a later developmental stage, shade is a contributing factor towards limiting diameter growth. Our results support the hypothesis that there are conflicting habitat requirements for trees at different developmental stages (Schupp 1995). Thus, in the context of future global warming (IPCC 2007) in a climatically sensitive ecotonal region of the aspen parkland, although moderated microclimates may act as micro-scale refugia or "safe sites" (Harper 1977) for tree seedling establishment, this may be at the expense of reduced growth at a later developmental stage. Models of forest growth in response to climate change should therefore take into account the role of conflicting habitat requirements for trees at different developmental stages.

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Natural Recolonization of Cultivated Land by Native Prairie Plants and its Enhancement by Removal of Scots Pine, *Pinus sylvestris*

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A combination of native and introduced plants colonized abandoned cultivated land with adjacent relict prairie and savanna in the Rice Lake region of southern Ontario. After 71 years, the native colonizers included 86 species found in regional prairie relicts, but much of the area was also colonized by introduced Scots Pine, *Pinus sylvestris*, which apparently spread from an adjacent planting. The pines formed expanding patches of dense growth that excluded other species. Removal of the invasive Scots Pine from a 200 m^2 plot within the abandoned land led to colonization 17 years later by 36 native species characteristic of the prairie, savanna and sand barrens of the region. Included in this group of native prairie colonizers were keystone species such as *Andropogon gerardii*, *Carex siccata*, *Ceanothus americanus*, *Comptonia peregrina* and *Quercus velutina*. Areas where patches of Scots Pine had been allowed to continue growing were either devoid of vegetation or had a sparse understory of introduced species and Poison Ivy (*Rhus radicans*). These observations support the concepts of (1) protecting islands of native dry ground flora which can serve as sources for recolonization and (2) protection of old field and particularly recently cultivated land adjacent to protected native grassland to allow natural restoration. The fact that keystone native species were able to colonize the area from which the introduced Scots Pines had been removed suggests that the pines are aggressive competitors that occupy space to the exclusion of the native species. Scots Pine is thus a driver of ecological change in degraded ecosystems. Management including removal of Scots Pine to support native plant biodiversity is strongly supported.

Key Words: Scots Pine, *Pinus sylvestris*, prairie, sand barren, savanna, recolonization, driver, *Andropogon gerardii*, *Carex siccata*, *Ceanothus americanus*, *Comptonia peregrina*, *Quercus velutina*, Rice Lake, Ontario.

Although information on restoration of prairie vegetation is abundant (e.g., Schramm 1992; Packard and Mutel 1997), information on natural recolonization of prairie flora following human impacts (e.g., Inouye et al. 1987; Rabinowitz and Rapp 1985) is relatively scarce. Despite the lack of information it is often considered a good idea to preserve degraded habitats that have islands of pristine habitat or have adjacent pristine habitats that can serve as sources for natural recolonization. It appears in some cases that invasive alien plants can limit the success of natural recolonization in these circumstances but a lack of information is apparent in this area as well. While some have expressed concern that invasive plant species are one of the leading direct causes of biodiversity loss (e.g., Catling 2005), others have questioned the extent to which introduced species threaten biodiversity (e.g., Davis 2003) and several recent articles have recommended changes in language and attitude in dealing with invasive species problems based to some extent on the need for more accurate information (Gobster 2005; Larson 2005). Recently it has been suggested that invasive plants are the passengers rather than the drivers of ecological change in degraded ecosystems (MacDougal and Turkington 2005). As "drivers" the invasives would compete with native species and may also change the environment to reduce the capability of native species to survive. As "passengers" they are not the limiting factor for native species but just along for the ride. MacDougal and Turkington (2005) suggested that if interactive processes were limiting, then removal of invasive plants should result in a direct increase in native species richness (the "driver" model). On the other hand, if invasive plants are not the limiting factor for native plants, then removal of the invasive plant(s) should have little effect (the "passenger" model).

Although common sense suggests that (1) natural recolonization could occur from pristine nuclei and (2) that invasive alien plants may be either drivers or passengers, the cost of managing natural areas requires stronger evidence. A simple field experiment conducted in the Rice Lake region of eastern Ontario provides information relating to these assumptions. It involves invasive alien Scots Pine (*Pinus sylvestris*) and a potentially diverse savanna, sand barren and prairie flora.

In situations where a native sand barren, prairie or savanna has been replaced by a dense stand of Scots Pine with a completely barren and dark understory (e.g., Catling and Carbyn 2005), it is compelling to think of this invasive as a "driver of ecological change" (Didham et al. 2005). Indeed, Scots Pine is listed as the fifth most significant invasive alien plant of natural habitats in Canada (Catling and Mitrow 2005). However, the present question is whether or not Scots Pine is a driver of ecological change in a degraded ecosystem where the native prairie vegetation has been reduced by other

factors. If following perturbation the native prairie species respond by colonizing an area of previously cultivated ground and they also respond by colonizing a portion of that same ground from which invading Scots Pine is removed, then native prairie plants do naturally recolonize and the introduced pine is a driver of ecological change that is clearly in the way since it is preventing the natural restoration of native flora following the cessation of degrading processes.

Methods

Natural Recolonization

The degraded ecosystem in this experiment originated from an area of sandy soil that was completely utilized for the cultivation of cereal crops and especially potatoes until 1935 when it was abandoned. It is located at 44.1268°N, 77.9839°W in Lot 4, Concession 7, originally Haldimand Twp. but now Alnwick/Haldimand township in Northumberland County, Ontario. The eradication of native flora is confirmed by BK whose family occupied the land, and further by aerial photographs taken in 1929. Cultivation was essentially continuous following settlement in the 1850s, but prior to this the region had been a rolling prairie dominated by prairie grasses with localized Black Oak (*Querus relutina*) Red Pine (*Pinus resinosa*) savanna and sand barren flora (Catling et al. 1992). By 2006 a combination of native species and alien species, including alien Scots Pine, had colonized the previously cultivated field. It had become a semi-open forest with 50-year-old pines, including the Scots Pine, along with the native White Pine (*Pinus strobus*) and both Red (*Querus rubra*) and Black oaks, but throughout the forest were openings of various sizes with a combination of native prairie species (see Table 1) and invasive alien species, including *Hypericum perforatum, Poa compressa, Hieracium pilloselloides, Rumex acetosella, Potentilla norvegica*, and especially *Pinus sylvestris*. Native species that have colonized the abandoned potato field are believed to have spread from the adjacent Russ Creek pioneer cemetery and from the adjacent Barr property preserve, which was never cultivated. The early pioneer graveyard dates from 1849 (earliest marker, although it had a schoolhouse beside it in 1845 and was likely used much earlier) with few burials after 1900. The prairie plant community in pioneer graveyards in prairie regions was usually not cultivated or grazed unlike much of the surrounding landscape because it was sacred ground. Since it was only controlled occasionally with a scythe, the prairie vegetation survived and this seems to be the case with the Russ Creek Cemetery, which is a nucleus of rare and restricted native prairie species. In 2006 an open (treeless) portion of the recolonized field that was 0.8 hectares in extent was selected as a sample plot to document recolonization of native species. All native plant species present in this sample plot were recorded during spring, summer and fall visits in 2006.

Effect of removing Scots Pine

The invading Scots Pines appeared to be preventing the re-colonization of native species in the old field since they grew in dense stands that contained no other species of vascular plants. In 1991 a dense stand of pines was removed from an area of 200 m^2 adjacent to the sample plot to allow colonization of native species. Beneath this stand, and beneath others within 100 m, the only plants at the time of tree removal were occasional depauperate specimens of Poison Ivy (*Rhus radicans*) which does well in the decomposing leaf litter of Scots Pine needles. In 2006 the area from which the trees were removed was surveyed and all native plant species present were recorded during spring, summer and fall visits. Native flora was also recorded from adjacent stands of Scots Pine (where the trees had not been removed).

Scientific and common names used in the text generally follow Kartesz and Meacham (1999). Representative specimens are at the AAFC (Agriculture and Agri-Food Canada) vascular plant herbarium in Ottawa (acronym – DAO).

Results and Discussion

Natural Colonization

In 2006, 71 years after the old potato field was abandoned as cultivated land, a total of 86 species characteristic of natural prairie, savanna and sand barrens in the region was recorded in the 0.8 hectare sample plot of an open (treeless) area (Table 1). It is clear that native species can recolonize seriously degraded habitat in this region but it is evidently a slow process since the occurrence of native species was still very patchy after 71 years despite a relatively uniform substrate and elevation throughout the area. The return of prairie flora to the previously cultivated field is to be expected on the basis of observations elsewhere where dispersal and colonization from adjacent protected sites have proven to be the major factors in old field succession (e.g., Inouye et al. 1987). The results of this study support the concept of protecting islands of native dry ground flora which can serve as sources for recolonization. The results also suggest that even in the northeastern-most prairie and savanna habitats, protection of previously cultivated land adjacent to protected native grassland is likely to result in an old field succession that includes many native prairie species. Furthermore, some studies have shown that the native prairie species increase with time (over 60 years) and with increasing soil nitrogen at the expense of both the introduced plants and native non-prairie plants (Inouye et al. 1987: Figure 8). Thus protection of abandoned farmlands adjacent to protected sites is likely to result in a degree of natural restoration that can be supported through plantings and management.

Effect of Removing Scots Pine

It is likely that the colonization by native species in the old potato field would have been more extensive

TABLE 1. Native species of prairie, savanna and sand barren habitats recorded in 2006 that naturally colonized a 0.8 ha tare plot of previously cultivated land abandoned in 1935. The native species recorded in the 200 m² subplot in 2006 (i.e., 15 years after removal of invading Scots Pines, are indicated with an asterisk (*).

Amelanchier arborea (Michx.) Fern. var. *arborea,* DOWNY SERVICE-BERRY
* *Amelanchier laevis* Wieg., ALLEGHENY SERVICE-BERRY
Amelanchier stolonifera Wieg., RUNNING SERVICE-BERRY
* *Andropogon gerardii* Vitman, BIG BLUESTEM
Anemone cylindrica Gray, LONG-HEAD THIMBLEWEED
Antennaria howellii ssp. *petaloidea* (Fern.) Bayer, SMALL PUSSYTOES
* *Antennaria parlinii* ssp. *fallax* (Greene) Bayer & Stebbins, PARLIN'S PUSSYTOES
* *Apocynum androsaemifolium* L., SPREADING DOGBANE
Aquilegia canadensis L., RED COLUMBINE
Arabis divaricarpa A. Nels., ROCKCRESS
Arabis hirsuta var. *pycnocarpa* (M. Hopkins) Rollins, HAIRY ROCKCRESS
Arabis holboellii var. *retrofracta* (Graham) Rydb., HOLBOELL'S ROCKCRESS
Arctostaphylos uva-ursi (L.) Spreng., RED BEARBERRY
Artemisia campestris ssp. *borealis* var. *scouleriana* (Hook.) Cronq., PACIFIC WORMWOOD
Asclepias exaltata L., POKE MILKWEED
* *Asclepias syriaca* L., COMMON MILKWEED
* *Asclepias tuberosa* ssp. *tuberosa*, BUTTERFLY MILKWEED
* *Calystegia spithamaea* ssp. *spithamaea*, LOW FALSE BINDWEED
* *Carex backii* Boott, BACK'S SEDGE
Carex gracillima Schwein., GRACEFUL SEDGE
* *Carex molesta* Mackenzie ex Bright, TROUBLESOME SEDGE
* *Carex muehlenbergii* var. *muehlenbergii*, MUHLENBERG'S SEDGE
Carex pensylvanica Lam., PENNSYLVANIA SEDGE
Carex richardsonii R. Br., RICHARDSON'S SEDGE
* *Carex siccata* Dewey, DRY-SPIKE SEDGE
* *Carex tonsa* var. *rugosperma* (Mackenzie) Crins
* *Ceanothus americanus* L., NEW JERSEY-TEA
Comandra umbellata ssp. *umbellata*, BASTARD TOADFLAX
* *Comptonia peregrina* (L.) Coult., SWEET-FERN
Cornus racemosa Lam., GRAY DOGWOOD
Cyperus houghtonii Torr., HOUGHTON'S FLAT SEDGE
Cyperus lupulinus (Spreng.) Marcks ssp. *lupulinus*, GREAT PLAINS FLAT SEDGE
* *Danthonia spicata* (L.) Beauv. *ex* Roemer & J.A. Schultes, POVERTY WILD OAT GRASS
* *Dichanthelium sabulorum* (Lam.) Gould & C.A. Clark *var. thinium* (A.S. Hitchc. & Chase) Gould and C.A Clark (*D. columbianum* Scribner), HEMLOCK ROSETTE GRASS
Dichanthelium depauperatum (Muhl.) Gould, STARVED ROSETTE GRASS
Dichanthelium linearifolium (Scribn. *ex* Nash) Gould, SLIM LEAF ROSETTE GRASS
Dichanthelium perlongum (Nash) Freckmann, LONG SLIM LEAF ROSETTE GRASS
Elymus trachycaulus ssp. *subsecundus* (Link) A.& D. Löve (includes *unilaterale*), SLENDER WILD RYE
* *Fragaria virginiana* Duchesne ssp. *virginiana,* VIRGINIA STRAWBERRY
Galium boreale L., NORTHERN BEDSTRAW
Galium circaezans Michx. var. *circaezans*, LICORICE BEDSTRAW
Helianthus divaricatus L., WOODLAND SUNFLOWER
Lechea intermedia var. *intermedia*, ROUND FRUIT PINWEED
Liatris cylindracea Michx., ONTARIO GAYFEATHER
Lilium philadelphicum L. var. *philadelphicum*, WOOD LILY
* *Maianthemum canadense* Desf., FALSE LILY-OF-THE-VALLEY
* *Maianthemum stellatum* (L.) Link (*Smilacina stellata*), STARRY FALSE SOLOMON'S SEAL
Melampyrum lineare Desr. var. *lineare,* AMERICAN COW WHEAT
Monarda fistulosa L. ssp. *fistulosa* var. *fistulosa,* OSWEGO-TEA
* *Physalis heterophylla* Nees, CLAMMY GROUND CHERRY
Penstemon hirsutus (L.) Willd., HAIRY BEARDTONGUE
Pinus strobus L., EASTERN WHITE PINE
* *Poa pratensis* L. ssp. *pratensis,* KENTUCKY BLUE GRASS
* *Polygala polygama* Walt., RACEMED MILKWORT
Polygonatum biflorum (Walt.) Ell. var. *commutatum* (J.A. and J.H. Schultes) Morong, KING SOLOMON'S-SEAL
* *Potentilla arguta* Pursh ssp. *arguta,* TALL CINQUEFOIL
Potentilla simplex Michx., OLDFIELD CINQUEFOIL
Prunus pumila L. var. *susquehanae* (hort. ex Willd.) Jaeger, SUSQUEHANNA SAND CHERRY
* *Prunus serotina* Ehrh., BLACK CHERRY
Prunus virginiana L. var. *virginiana,* CHOKE CHERRY

TABLE 1. (*cont.*)

Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underwood ex Heller, NORTHERN BRACKEN FERN
Quercus alba L., NORTHERN WHITE OAK
Quercus rubra L., NORTHERN RED OAK
* *Quercus velutina* Lam., BLACK OAK
Ranunculus rhomboideus Goldie, LABRADOR BUTTERCUP
* *Rhus typhina* L., SLIM LEAF ROSETTE GRASS
* *Rosa acicularis* Lindl. ssp. *acicularis*, PRICKLY ROSE
* *Rosa blanda* Ait. var. *blanda*, SMOOTH ROSE
* *Rubus idaeus* L. ssp. *idaeus*, COMMON RED RASPBERRY
Rudbeckia hirta L. var. *hirta*, BLACK-EYED SUSAN
Salix humilis Marsh var. *humilis*, PRAIRIE WILLOW
Schizachyrium scoparium (Michx.) Nash var. *scoparium*, LITTLE FALSE BLUESTEM
Shepherdia canadensis (L.) Nutt., RUSSET BUFFALO-BERRY
Solidago canadensis L. var. *canadensis*, CANADA GOLDENROD
Solidago gigantea Ait., LATE GOLDENROD
* *Solidago juncea* Ait., EARLY GOLDENROD
* *Solidago nemoralis* Ait. var. *nemoralis*, GRAY GOLDENROD
Sorghastrum nutans (L.) Nash, YELLOW INDIAN GRASS
* *Symphyotrichum ericoides* (L.) Nesom var. *ericoides*, WHITE HEATH AMERICAN-ASTER
* *Symphyotrichum novae-angliae* (L.) Nesom, NEW ENGLAND ASTER
* *Symphyotrichum oolentangiense* (Riddell) Nesom var. *oolentangiense*, SKY-BLUE ASTER
* *Toxicodendron rydbergii* (Small ex Rydb.) Greene, WESTERN POISON IVY
Viola adunca Sm. var. *adunca*, HOOK-SPUR VIOLET
* *Viola sagittata* Ait. var. *ovata* (Nutt.) Torr. & Gray, ARROW-LEAF VIOLET
Vitis riparia Michx., RIVER-BANK GRAPE

and less patchy if the Scots Pines had not invaded. Scattered dense stands of Scots Pine were without other species in 1991 and in 2006. However, within the recolonized area of the old field where the Scots Pines were removed in 1991, 36 native species of prairie, savanna and sand barren affinity were found in 2006, and had thus colonized this space within 15 years (Table 1). The absence of native species under the dense Scots Pines that remained suggested that this colonization would not have occurred if the pines had not been removed.

Although introduced species had also colonized this area from which the Scots Pines were removed, including particularly *Poa compressa, Hieracium piloselloides* and young Scots Pines, the native species were at least 50% of the cover. Therefore, the pines occupy space to the exclusion of the native species and restrict recolonization of disturbed sites. Since only more pines and Poison Ivy and raspberries *Rubus* spp. occur in the older (more than 50 years old) Scots Pine stands in the region, there is very good evidence that the Scots Pines interfere with the recolonization of native prairie species following cessation of degrading processes and apparently also change the environment to reduce the capability of native species to survive. In adjacent stands of Scots Pines the understory was bare or covered only by a scant growth of Poison Ivy, raspberries, and introduced plants. The native species that responded to the removal of the pines included the characteristic and keystone native species of prairie, savanna and sand barren such as *Andropogon gerardii, Carex siccata, Ceanothus americanus, Comptonia peregrina* and *Quercus velutina*. The fact that these native species were able to colonize the area from which the pines were removed, but did not where the pines remained, suggests that the pines are aggressive competitors that occupy space to the exclusion of the native species and change conditions by competing for nutrients, reducing light and changing soil characteristics with leaf litter accumulation, so that most of the native species of prairie, savanna and sand barren cannot exist. Scots Pine in this situation and evidently in many other situations (e.g., Catling and Carbyn 2005) is thus a driver of ecological change. Management including removal of Scots Pine to support native plant biodiversity is strongly supported. Since the trees are relatively slow growing, slow to mature, reproduce only by seed, are conspicuous at all times, and easily eliminated by pulling and cutting and/or burning, control of Scots Pine is much less problematic than the control of some other invasive plant species.

Conclusion

These observations suggest that natural recolonization by native prairie species can occur, but that it is hindered by invasive alien Scots Pine, which drives ecological change in a degraded prairie ecosystem.

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Notes

A High Elevation Record of the Star-nosed Mole (*Condylura cristata*) in Northeastern Vermont

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Norris, Ryan W., and C. William Kilpatrick. 2007. A high elevation record of the Star-nosed Mole (*Condylura cristata*) in northeastern Vermont. Canadian Field-Naturalist 121(2): 206-207.

A single male Star-nosed Mole, *Condylura cristata*, was captured in a rock pile at the top of East Mountain (elevation 1042 m; 3240 ft) in northeastern Vermont. Although known from high elevations (up to 1676 m; 5500 ft) in southern U.S. states, this species was not known to occur above 573 m (1880 ft) in the northern part of its range. This record is also important in confirming that *C. cristata* has some climbing ability when travelling above ground.

Key Words: Star-nosed Mole, *Condylura cristata*, elevation, talus, Vermont.

The Star-nosed Mole, *Condylura cristata*, has the largest and most northerly geographic range of all North American moles (Peterson 1966; Hall 1981). The species ranges from southwest Manitoba to Labrador and Nova Scotia, down the eastern United States to South Carolina, and to the Great Lakes region (Petersen and Yates 1980). The species is known to be associated with moist soils near marshes and streams and is an excellent swimmer (Hamilton 1931; Petersen and Yates 1980). Habitat preference for the Star-nosed Mole is usually characterized as low wet ground near bodies of water, swamps, wet meadows, wet spots in fields or low-lying woods, and dry soils within mixed hardwoods near water (Godin 1977; DeGraaf and Yamasaki 2001).

Beane (1995), Laerm et al. (1997), and McCay et al. (1999) have suggested that *C. cristata* is quite common in high elevations in states at the southern edge of its distribution such as North Carolina and South Carolina. Elevational records reported for southern U.S. states include a record at 760 m (2494 ft) in South Carolina (Laerm et al. 1997) and several individuals from the Smoky Mountain National Park at elevations ranging from 488 to 1676 m (1600-5500 ft; Linzey and Linzey 1971). Literature records from Canada and northern U.S. states rarely report elevation, but all available records are lower. The highest elevation reported at northern latitudes that we have been able to find is Saunders's (1988) suggestion that *C. cristata* ranges up to 573 m (1880 ft) in elevation in the Adirondacks of New York.

Study Area and Methods

The summit of East Mountain in northeastern Vermont was modified in 1955 with the construction of the North Concord Air Force Station. The ridgeline was levelled creating an area of approximately 17 acres on the summit for this radar station. The rubble from this modification was pushed to the edges, levelling the surface and creating substantial areas of talus. The station was deactivated in 1963; the buildings have slowly deteriorated, and have been partially dismantled. The native fauna and flora have since recolonized the modified area. Dense regenerative spruce-fir forest now covers much of the summit and small mammals associated with talus habitat, such as the Yellow-nosed Vole (*Microtus chrotorrhinus*), have been found in this human-made talus habitat.

During a small mammal survey, 30 Sherman live traps, baited with rolled oats, were set in and adjacent to one of several human-made talus piles at the top of East Mountain (elevation 1042 m or 3420 ft), East Haven township, Essex County, Vermont, 44°39.5'N 71°46.1'W over three nights (23-25 August 2004). Traps were checked daily and rebaited as needed. The talus pile was approximately 20 m in diameter and contained bare, flattish rocks ranging from ~ 0.5 m to 3 m in diameter. It was located on a gentle slope and had small pools of standing water. No larger streams or bodies of water were observed in the vicinity. Traps in the talus were placed on rocks, not soil, but a small quantity of humus had collected in some areas.

Results

A single male *C. cristata* was discovered dead in a Sherman trap placed among rocks approximately 5 m from the edge of the talus pile on the first night of trapping (23 August). This night saw moderate rain with nighttime low temperatures at or approaching 0°C. The measurements of this specimen are: total

length 174 mm, tail length 80 mm, and hind foot length 27 mm. Skin, skull, and tissue are housed in the Zadock Thompson Natural History Museum at the University of Vermont (catalog number 5273). Other species captured over the course of these three nights of trapping were Short-tailed Shrew, *Blarina brevicauda* (1); Smokey Shrew, *Sorex fumeus* (1), Southern Red-backed Vole, *Myodes gapperi* (5), and Deer Mouse, *Peromyscus maniculatus* (8).

Discussion

The Star-nosed Mole, *Condylura cristata*, is clearly a more northern-adapted species than other moles in eastern North America. The relatively high number of reports of this species in mountainous areas in southern states is not surprising considering its distribution as far north as Labrador. Our capture of the species at a high elevation site in Vermont was unexpected, particularly considering that it was taken in a talus pile and not associated with soil or long-term standing water. The single specimen reported here is evidence that the Star-nosed Mole also occurs at high elevations (at least 1042 m; 3420 ft) even in the northeastern USA. This capture also suggests that they can live, or travel through, rocky areas away from soil. Peterson (1966) suggested that Star-nosed Moles spend more time above ground than other mole species and, as a result, are occasionally found dead on the surface or captured on the surface with snap or live traps.

The capture of the mole amongst rocks and not on bare soil suggests that it must have been maneuvering within this rock pile. Hickman (1982) reported observing a vertical climb of 60 cm by a Star-nosed Mole in the corner of a concrete column, and Schmidt (1931) reported a Star-nosed Mole climbing two feet out of a swimming tank. Our capture provides further indication that *C. cristata* is capable of some degree of climbing, a feature not often attributed to fossorially adapted mammals. Hickman (1982) hypothesized that the climbing ability of *C. cristata* may serve to aid in mobility across rocky areas. Our capture is also consistent with this idea.

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Northern Long-eared Bat, *Myotis septentrionalis* (Chiroptera: Vespertilionidae), on Prince Edward Island: First Records of Occurrence and Over-Wintering

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First occurrence of the Northern Long-eared Bat, *Myotis septentrionalis*, on Prince Edward Island is reported. A mixed-species hibernaculum of *M. septentrionalis* and the Little Brown Bat, *M. lucifugus*, is also described from southeastern Prince Edward Island. This is the first record of bats over-wintering in the province and the first time either species has been reported making use of a building as a hibernaculum.

Key Words: Little Brown Bat, *Myotis lucifugus*, Northern Long-eared Bat, *Myotis septentrionalis*, Prince Edward Island, distribution, hibernaculum.

The bats of Prince Edward Island are poorly known. Although seven species have been recorded from the adjacent mainland of New Brunswick and Nova Scotia (van Zyll de Jong 1985), only the Little Brown Bat (*Myotis lucifugus*) and Hoary Bat (*Lasiurus cinereus*) are known from the Island (van Zyll de Jong 1985; McAlpine et al. 2002). Cameron (1958) reported a sighting which he believed to be a Red Bat (*Lasiurus borealis*) near coastal Fortune Bridge, Kings County, Prince Edward Island (46°21'23"N 62°29'57"W) on 7 June 1954, but this species remains unconfirmed on the Island. Neither have any bat species been documented to hibernate on Prince Edward Island. Here we document the first occurrence of the Northern Long-eared Bat (*Myotis septentrionalis*) from the province and report a mixed-species hibernaculum of *M. lucifugus* and *M. septentrionalis* from southeastern Prince Edward Island.

On 24 September 1988, two bats retrieved by a house cat (*Felis domesticus*) were collected in Breadalbane, Queens County, Prince Edward Island (46°21'23"N 63°29'57"W) by JAB and subsequently identified as *M. septentrionalis*. These specimens, deposited in the Canadian Museum of Nature (CMN), include a male (CMN 52612) and a female (CMN 52613). Measurements for both bats (M (male), TL (total length) 85 mm, T (tail) 37 mm, HF (hind foot) 10 mm; F (female), TL 90 mm, T 36 mm, HF 10 mm) fall within the range for the species presented by van Zyll de Jong (1985).

On or about 10 January 1989 a commercial pest control officer removed about 800 bats, both Little Brown and Northern Long-eared bats, from the basement of a home at Culloden, Queens County, Prince Edward Island (46°0'58"N 62°42'8"W; reported in the media as Murray River, the larger nearby community). All bats were destined to be incinerated. However, DFM was able to secure 781 of these bats alive and an unsuccessful attempt was made to maintain them in a state of torpor over the winter with the intention of spring release. Various media reports suggest that the hibernaculum contained 1500 bats (Anonymous 1989*; Cody 1989 a*, b*; White 1989*). However, communication with the pest control officer (personal communication to DFM) confirmed that all hibernating bats observed were removed. Information presented here is based on an examination of all 781 bats, apparently the contents of virtually the entire hibernaculum. We visited the hibernaculum site on 29 November 1990 and found only two torpid female *M. septentrionalis,* clinging to wooden floor joists. A voucher series of both species from the site have been deposited in the mammal collection of the New Brunswick Museum.

The hibernation site was the unheated basement of an occupied home, built about 1980. The house had been recently re-occupied following a 3-5 year vacancy (resident personal communication to DFM). The basement had an earthen floor and island stone and mortar foundation walls with inside dimensions about 11 × 8 m and a ceiling height of 1-2 m. Entry to the basement was via a trap door on the first floor. Air temperature in the hibernaculum recorded on the night of 29 November 1990 was 11.3°C. This hibernation temperature, while above the mode of 6°C for vespertilionids, falls within the range of -4° to 13°C and 0.6°C to 13.9°C reported for Little Brown and Northern Long-eared bats; respectively (Webb et al. 1996). The hibernaculum was dominated by the Little Brown Bat (82.6%); with smaller numbers of the Northern Long-eared (17.4%). In both species sex ratios were slightly

female biased (62.1% and 57.1% in *M. lucifugus* and *M. septentrionalis*, respectively). We also assessed reproductive status by dissection of all Northern Long-eared Bats following the criteria and terminology of Sluiter and Bouman (1951), Sluiter (1954, 1961), and Racey (1974), with the following results: males; 5.9% sexually immature, 94.1% sexually mature; females; 17.5% nulliparous, 14.2% nonparous, 68.3% parous.

The Northern Long-eared Bat is widespread across Atlantic Canada (van Zyll de Jong 1985). Although less abundant, apparently, in the region than the Little Brown Bat, the presence of the Northern Long-eared Bat on Prince Edward Island is not unexpected. Culloden and Breadalbane are 67 km straight-line distance apart, suggesting *M. septentrionalis* may be widespread in the province. Conversely, the discovery of large numbers of hibernating bats on the Island was unanticipated. The province is underlain largely by Permian sandstones, siltstone and glystone (van de Poll 1983) and we are aware of no natural caves or abandoned mines on the Island that might provide suitable hibernacula. The closest natural caves serving as bat hibernacula occur in adjacent New Brunswick and Nova Scotia (McAlpine 1983; Mosely 2007). Fenton and Barclay (1980) were unable to locate any records of Little Brown Bats hibernating in buildings. Likewise, the Northern Long-eared has previously only been recorded hibernating in caves and mines (van Zyll de Jong 1985). Both these species of *Myotis* may be more flexible in their hibernation requirements than the literature suggests, being able to rapidly exploit suitable artificial hibernacula where present.

Acknowledgments

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Arboreal Late Summer Courtship Behaviour of Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, in Dartmouth, Nova Scotia, Canada

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Gilhen, John, and Robert Strum. 2007. Arboreal late summer courtship behaviour of Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, in Dartmouth, Nova Scotia, Canada. Canadian Field-Naturalist 121(2): 210-211.

We report, for the first time, Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, arboreal, late summer, courtship behaviour in the wild observed 4-5 September 2006.

Key Words: Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, arboreal, late summer, courtship behaviour, Dartmouth, Nova Scotia, Canada.

On the morning of 5 September 2006 Robert Strum reported to John Gilhen that a ball of snakes had gathered on a Rhododendron shrub, *Rhododendron* sp., in his yard at 325 Prince Albert Road, Dartmouth, Nova Scotia. In the afternoon of the previous day, 4 September 2006, Robert Strum could see, from the kitchen window, that a number of brown snakes had gathered inside a gazebo style bird feeder on the Rhododendron shrub and he was successful in moving them out. The following morning, 5 September 2006, he noticed the snakes had gathered, again, on a branch near the bird feeder, about two meters above the ground (Cover). Upon investigation it was determined that there were four (three males and one female) Maritime Garter Snakes, *Thamnophis sirtalis pallidulus*, involved in courtship behaviour: male number 1, the largest male; males 2 and 3 about equal total length; and 1 female (the largest of the four snakes). The weather at 1200 hours on 5 September 2006 was cloudy and overcast with ambient air temperature of 20°C and temperature near the ground was also 20°C.

At 1215 hours the males were observed moving alongside and over the back of the female. At the same time the body of male number 1 was pulsating rhythmically. This male rubbed his chin along the sides of the female. At this time the tail and about one half of the female's posterior trunk (about 20 cm) drooped downward from one of the supporting branches, with the tails of all three males wrapped around her tail. While the female's posterior body and tail were dangling down, the most active male (male number 1) appeared to maintain ventral apposition to copulate with her (Figure 1).

All four snakes remained on the Rhododendron shrub from the morning to early afternoon but dispersed at some time late in the afternoon, as they were not seen there again that evening or in the following days. It is not known if copulation occurred over the two-day period these snakes occupied the Rhododendron shrub. One of the two subordinate males was collected as a voucher specimen (NSM55388).

Courtship behaviour of the Maritime Garter Snake in captivity has been previously observed by John Gilhen in late August (unpublished). On two separate occasions (August 2001 and August 2004), days after individual females had given birth, two males were observed following alongside the female and trying to attain cloacal apposition. Although other adult females were present in the enclosure, the males were only interested in courting with a recently spent female. These observations of captives and the present observation in the wild suggests that the Maritime Garter Snake mates in late summer, sometime after females give birth, but prior to hibernation.

Galbraith (2001) reports similar arboreal late summer courtship by Eastern Garter Snakes, *Thamnophis sirtalis sirtalis*. Cook (1984) mentions snakes in the genus *Thamnophis* most frequently copulate in spring but have occasionally been noted to copulate in late fall, immediately prior to entering hibernacula. Arboreal spring breeding activity of the Red-sided Garter Snake, *Thamnophis sirtalis parietalis*, was observed on 8 May 1972 near Inwood, Manitoba (Gregory 1975).

Rossman et al. (1996) and Ernst and Ernst (2003) agree mating of *Thamnophis sirtalis* usually occurs in spring after emergence from hibernation but may also take place in autumn. Rossman et al. (1996) also states that, until recently, most of the studies of mating behavior and the factors that regulate the timing of reproduction in *T. sirtalis* have focused primarily if not exclusively on spring activities. Previous accounts of the species in Nova Scotia (Barnes et al. 2006; Gilhen 1984, 2000), have not noted fall mating.

The urbanization of both Halifax and Dartmouth cities over the past two decades has been extensive leaving many isolated pockets of amphibians and reptiles. The Maritime Garter Snakes at the observation site in Dartmouth continue to survive in small numbers in a back yard landscape, surrounded by apartment buildings on the south side, a major city road on the north side and other homes on the east and west sides. Galbraith's (2001) observation of the Eastern Garter

FIGURE 1. An adult male Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, seeking ventral apposition with adult female in courtship behavior on the branches of a Rhododendron shrub at 325 Prince Albert Road, Dartmouth, Nova Scotia, on 5 September 2006.

Snake also took place on private land in a cottage community on the coast sand dune area of the eastern shore of Lake Huron in Ontario.

In Nova Scotia, the Maritime Garter Snake is most common along the shores of lakes, ponds and streams but has readily adapted to a host of urban habitats. Robert Strum has commonly observed Maritime Garter Snakes in his yard and has noted they move down along the base of the swimming pool and probably hibernate under the pool.

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Human-assisted Movements of Raccoons, *Procyon lotor,* and Opossums, *Didelphis virginiana*, between the United States and Canada

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Rosatte, Rick, Dennis Donovan, Mike Allan, Laura Bruce, and Chris Davies. 2007. Human-assisted Movements of Raccoons, *Procyon lotor*, and Opossums, *Didelphis virginiana*, between the United States and Canada. Canadian Field-Naturalist 121(2): 212-213.

Movements of Raccoons (*Procyon lotor*) ($\bar{x}$ = 479 km) and Opossums (*Didelphis virginiana*) ($\bar{x}$ = 688 km) by means of transport trailers and a train from the USA and Quebec into Ontario were significantly greater than Raccoon movements ($\bar{x}$ = 15 km) from Ontario to New York State determined by mark-recapture. Human-assisted movements of wildlife could have significant impacts with respect to cross-border movements of diseases such as rabies. Proactive communication programs, especially at International border crossing areas, should be encouraged to decrease the occurrence of the unintentional movement of wildlife and associated diseases.

Key Words: *Didelphis virginiana,* Opossum, *Procyon lotor*, Raccoon, movement, disease, rabies, Ontario.

The movement of wildlife and domestic animals by humans has resulted in the national, international, and sometimes global movement of diseases such as rabies, West Nile virus, bovine tuberculosis, parvovirus, chronic wasting disease (CWD), and bovine spongiform encephalopathy (BSE) (Jenkins and Winkler 1987; Nielson and Brown 1988; Woodford and Rossiter 1993; Williams and Barker 2001). The international movement of Raccoons (*Procyon lotor*) from the United States to Ontario, Canada, has been documented previously (Rosatte et al. 1997, 2001); however, those publications did not document the distances moved or geographic areas involved.

During January 1997 and December 2005, a total of 14 Raccoons were documented as having moved across the St. Lawrence and Niagara Rivers from Ontario, Canada, to New York State. Those Raccoons were eartagged and released in Ontario as part of a wildlife rabies control program during 1997-2005 (Rosatte et al. 1997, 2001). They were later recaptured or found dead in the vicinity of Buffalo or Ogdensburg, New York (Figure 1). Exact locations were known for 13 of those. Mean movement of the 13 Raccoons was 15 km (SD=9.0) (range = 3-30 km). The sex and age were known for 11 of the 13 Raccoons. More adult males (9) than adult females (2) moved from Ontario to New York (Chi Square = 8.9; $P<0.0028$). Mean movement (18 km, SD=8.4) (range = 6-30 km) of adult male Raccoons was greater than mean movement of adult females (7.5 km, SD=6.4) (range=3-12 km) (t=1.65; $P=0.13$).

In addition, during 1998-2005, a total of 14 Raccoons and two Opossums (*Didelphis virginiana*) were found in transport trailers and in a box car on a train in the greater Toronto area. The point of departure of those vehicles included Ohio, Illinois, Tennessee, New York, Michigan, Quebec, and Ontario (Figure 1). In most cases the trailer or container was locked and sealed at the point of departure and was not opened until it arrived in Ontario. Mean movement of Raccoons by vehicle from the USA and Quebec (n=11) to Ontario, Canada, was 479 km (SD=250) (range=250-890 km). This was significantly greater (t=6.9, $P<0.00002$) than movements of Raccoons noted above that did not involve transport via vehicles. The two Opossums moved 1000 km from Tennessee and 376 km from Michigan, respectively.

In Ontario, rabid Raccoons have been documented as having moved 0.7-4.1 km (Rosatte et al. 2005, 2006). Median movements of non-rabid Raccoons in Ontario were generally less than 1 km, with movements rarely exceeding 50 km in distance (Rosatte 2000; Rosatte et al. 2006). However, those movements were assumed not to have been due to human involvement (intentional or otherwise) (i.e. by vehicles). The exceptional movements for Raccoons, as well as Opossums, documented in this paper, indicate that those species have the potential to move infectious diseases such as rabies significant distances. In view of this, people should be vigilant for wildlife such as Raccoons riding on vehicles. Transport trailer drivers (as well as operators of other vehicles such as ferries, trains, boats) should be encouraged to check their vehicles and trailers for wildlife prior to departure to minimize the unintentional movement of animals. This will assist in decreasing the movement of wildlife diseases. Signage at international border crossing areas advising drivers to check their vehicles for wildlife should also be posted. These tactics were used during the 1990s in Ontario in an attempt to prevent the movement of Raccoon rabies from the United States to Canada (Rosatte et al. 1997).

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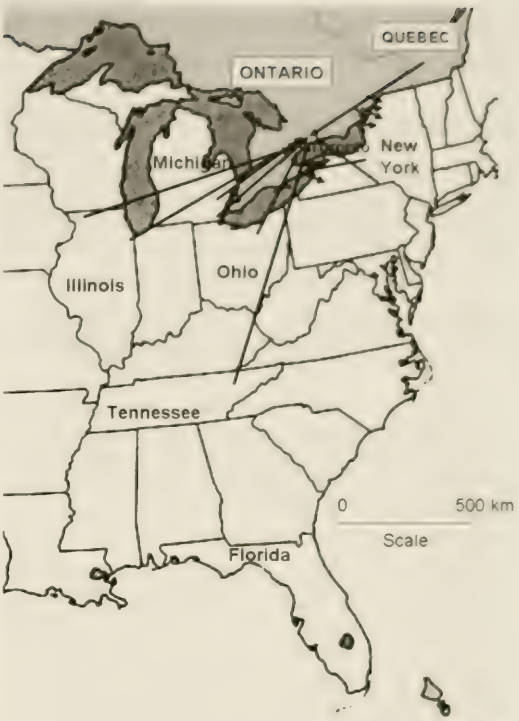

FIGURE 1. Map depicting Raccoon movement to and from Ontario, Canada. Direction of arrows represents direction of Raccoon movements. Arrows depicting movements of > 30 km represent Raccoon movement via transport trailers. One arrow in Michigan represents Raccoon movement on a train. Arrows depicting movements of < 30 km probably represent natural Raccoon movements (i.e. not human assisted). Locations of arrows are approximate.

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Correlation Between Age Estimates for Elk, *Cervus Elaphus*, Using Tooth Wear/Eruption Patterns and Counts of Annuli in Tooth Cementum

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Rosatte, Rick, Andrew Silver, Mark Gibson, Bruce Chisholm, and Norm Cool. 2007. Correlation between age estimates for Elk, *Cervus elaphus*, using tooth wear/eruption patterns and annuli in tooth cementum. Canadian Field-Naturalist 121(2): 214-215.

Two different techniques, (1) tooth wear, tooth eruption patterns and other attributes and (2) counting annuli and seasonal growth zones in the cementum of incisor teeth, were used to estimate the age of Elk, *Cervus elaphus*, that were relocated from Alberta to Ontario, Canada. Age estimates for Elk ranged from 2 to 20 years, and a significant relationship was found between the ages acquired by the two methods. Critical to acquiring accurate age estimates for Elk were staff with extensive skill with respect to the aging technique utilized.

Key Words: Elk, *Cervus elaphus*, age estimates, annuli, cementum, tooth wear.

During 1998-2001, 443 Elk (*Cervus elaphus*) were acquired from Elk Island National Park (EINP), Alberta, Canada, and released in four different areas of Ontario, Canada (Rosatte et al. 2002; Rosatte et al. 2007). Elk were aged according to tooth wear, eruption patterns (deciduous and permanent teeth), colouring and staining of teeth, as well as by comparison to a reference sample of known-age Elk jaws, during processing at EINP (Hudson et al. 2002) (Figure 1). By about two years of age the upper pair of permanent incisiform canines erupt (the ivory) and by about 3 years of age, the 4 pairs of permanent incisors have erupted. The weight of the animal was also considered when estimating the age of Elk at EINP; e.g., the weight of 7-month-old calves, 1½-year-old, and ≥ 2½-year-old Elk was approximately 100-120 kg, 130-170 kg, and > 180 kg (± 10 kg), respectively. The weights of the Elk were checked following age estimation to ensure that the age estimate fell into the above age/weight categories.

During 1999-2004, incisor teeth were collected opportunistically from Elk that died in Ontario post-release. These teeth were aged via counting annuli and seasonal growth zones in tooth cementum (Figure 2). The annuli or rings in the cementum represent yearly growth. By counting the number of annuli in the cementum an estimate of the animals age can be determined (Johnston et al. 1999). The age estimates were compared with those obtained during processing at EINP after the tooth wear age estimates were extrapolated to coincide with the time of death of the Elk in Ontario. Staff involved in aging had many years of experience with the aging technique.

Incisor teeth were extracted (via tooth extractors) from a sample (n = 10) of Elk that died in Ontario post-release. Two yearling bulls, for which the age was known, served as controls. Teeth were cleaned of tissue and soaked in 70% ethanol for 5 minutes to prevent the transmission of infectious pathogens. They were then preserved in 10% formalin or frozen at -20°C. Teeth were sectioned using an Isomet double-bladed saw (Buehler Isomet, Techmet, Scarborough, Ontario) according to Johnston et al. (1999). Each section (60-100μ) was mounted on a microscope slide with Per-

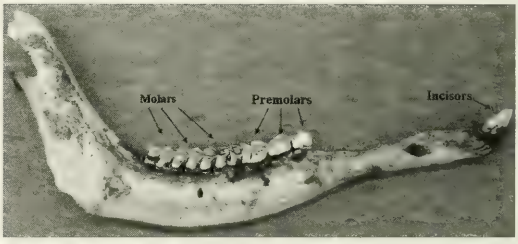

FIGURE 1. Photo of an Elk (*Cervus elaphus*) mandible showing incisor, premolar, and molar teeth.

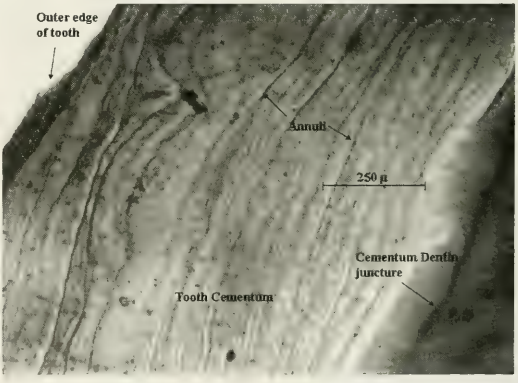

FIGURE 2. Longitudinal section (decalcified, Harris modified hematoxylin stain using bright field illumination) of an incisor tooth (100× magnification) from an Elk (*Cervus elaphus*) depicting annual growth lines (annuli) in the cementum. Estimated age is 20 years.

mount and covered with a cover slip. Two microscopic techniques were used to determine an age estimate for each incisor. To distinguish juveniles from adults, the undecalcified, unstained sections were viewed under a compound light microscope (50× and 100× magnification) using polarized light to view seasonal grow zones. In the majority of sections (especially older animals), the annuli were not distinct and not easily discerned under polarized light. These were decalcified (according to Johnston et al. 1999), stained (Harris modified hematoxylin), and placed in 70% ethanol for 2-3 minutes. Slides were then air-dried, covered with Permount and a cover slip, and examined under the microscope (unpolarized light) to count the number of annuli to obtain an estimate of age (Johnston et al. 1999) (Figure 2).

Age estimates for Elk acquired by tooth wear (and other indicators as noted above) and annuli or seasonal growth zone counts in incisor teeth, ranged between 2 and 20 years of age (Figure 3). The first week of June was used as the birth date for Elk (Hudson et al. 2002). A simple linear correlation and a t statistic (Zar 1974) were used (Statistica 6.0 software, StatSoft, Tulsa, Oklahoma, USA) to measure the relationship and level of significance between tooth wear and counting annuli for age determination in Elk. The correlation was found to be significant ($P < 0.0001$; $t = 20.1$; $r = 0.9903$; $r^2 = 0.98$). There was a positive slope of 1.09 between the ages acquired by the two methods ($Y = 1.0918 x = 1.261$) (Figure 3).

This study examined the relationship between two methods used to estimate the ages of wild Elk. Tooth wear estimates of age may be inexact as tooth wear could be affected by diet, soil type and substrate (Hudson et al. 2002). However, as the Elk at EINP were in an enclosed (fenced) situation, these variables were fairly constant as their geographical location remained unchanged among years. Therefore, we believe the age estimates acquired by tooth wear (and other attributes that were examined) were fairly accurate. Some authors (Keiss 1969; Hamlin et al. 2000; Hudson et al. 2002) suggest that staining sections of teeth and counting annuli provides the most reliable estimate of age for Elk. Furthermore, Keiss (1969) and Hamlin et al. (2000) only found about a 50% agreement between tooth eruption/wear and cementum annuli counts and concluded that wear/eruption estimates are unreliable for aging Elk. On the contrary, in our study, although the sample size was small, age estimates for Elk obtained by tooth wear correlated well with those acquired by counting annuli in stained and unstained sections of incisor teeth. We believe that the different result in this study was due to staff expertise with both aging techniques and that this is critical to obtaining accurate age estimates for Elk.

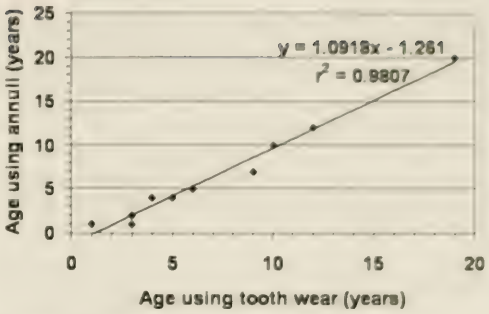

FIGURE 3. Relationship between age of Elk (*Cervus elaphus*) determined by tooth wear and annual growth lines (annuli) in tooth cementum ($n = 10$).

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Predator-Prey Interaction Between an American Robin, *Turdus migratorius*, and a Five-lined Skink, *Eumeces fasciatus*

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Vanderhoff, E. Natasha. 2007. Predator-prey Interaction between an American Robin, *Turdus migratorius*, and a Five-lined Skink, *Eumeces fasciatus*. Canadian Field-Naturalist 121(2): 216-218.

I observed a predator-prey interaction between a juvenile American Robin (*Turdus migratorius* L.) and a juvenile Five-lined Skink (*Eumeces fasciatus* L.). Although Robins are considered omnivorous, there are no previous reports of a robin eating lizards although they have been recorded as occasionally taking snakes. I discuss the age of the individuals involved as it relates to prey capture and escape.

Key Words: American Robin, *Turdus migratorius*, Five-lined Skink, *Eumeces fasciatus*, predation.

The American Robin (*Turdus migratorius* Linnaeus) and Five-lined Skink (*Eumeces fasciatus* Linnaeus) are commonly found in deciduous forests, as well as rural and urban areas and parks, in eastern North America. However, although they inhabit the same areas, there have been no accounts of predator-prey interactions between these two species. The American Robin, the most common thrush species in North America, is a versatile forager, feeding largely on invertebrates during the spring and summer and shifting to a diet with more fruits in the fall and winter (Sallabanks and James 1999; Wheelwright 1986). Robins also occasionally consume vertebrate prey, including snakes (Davis 1969; Netting 1969; Richmond 1975; Erickson 1978), shrews (Powers 1973), and even fish (Bayer 1980; Kimball 1944). However, there are no published records of Robins pursuing or consuming any species of lizard (Sallabanks and James 1999).

The Five-lined Skink is a small lizard associated with forest openings throughout the eastern United States and southern Ontario (Fitch 1954; Behler and King 1997). Juveniles and adults differ in their appearance; adults develop a solid brownish color, whereas juveniles have five light-colored stripes on a black body and a bright blue tail (Behler and King 1997). Juveniles can lose their blue tail (autotomy) during interactions with predators. This, along with their striped pattern, is thought to confuse predators and allow the skink to escape (Fitch 1954; Clark and Hall 1970; Vitt and Cooper 1986; Goodman 2006). Numerous mammalian and reptilian predators of the Five-lined Skink have been documented (Fitch 1954). Although several birds, including mimids, icterids, corvids, and accipiters, prey upon lizards (Cooper and Vitt 1985), the American Robin has not been known to prey upon lizards. Additionally, there have only been a few confirmed avian predators of the Five-lined Skink, including the American Kestrel (*Falco sparverius*) (Heintzelman 1964), Broad-winged Hawk (*Buteo platypterus*) (Fitch 1974), Cooper's Hawk (*Accipiter cooperii*) (Toland 1985), Greater Roadrunner (*Geococcyx californianus*) (Brown 1963) and Red-shouldered Hawk (*Buteo lineatus*) (Fitch et al. 1946).

I observed a predator-prey interaction between an American Robin and a Five-lined Skink on 24 August 2006 at Joe Creason Park in Jefferson County, Kentucky (38°12'N 85°42'W). The interaction took place in a field at the edge of a forested area and I used 10 × 43 binoculars to aid my observations. The initial observations of two juvenile robins (J1 and J2), and the juvenile skink were made from a distance of over 20 m. Subsequent observations of J2 were made from about 10 m. At 18:18 I observed J1 with a skink in its beak. At 18:19 J2 approached J1, at which point the skink escaped by jumping out of J1's beak. The robins pursued the skink for approximately 30 cm; J2 captured the skink and carried it approximately 5 m away while J1 flew off. I moved closer and observed the robin handle and consume the skink over the next six minutes. The robin, holding the skink in its beak, beat the skink on the ground multiple times and then took several bites. The robin repeated this four times, stopping periodically to stand alert and scan the area. The robin also took one large bite and swallowed a large portion of the skink. After the robin flew off, I examined the spot and found only the skink's entrails. Closer examination of the site where the skink was initially captured revealed the skink's blue tail. Although I was unable to measure the skink, based on the tail remnant and entrails the skink was approximately 90 mm.

This is the first account of a predator-prey interaction between the American Robin and the Five-lined Skink. The Five-lined Skink spends most of its time under cover such as woody debris and thus may largely avoid predation from avian foragers (Fitch 1954). However, the ranges and habitat of both species overlap, and it is likely that skinks may occasionally be pursued and successfully captured by robins. At least one other thrush species is known to consume skinks; *Turdus caleanops* of Japan has been recorded to prey upon juvenile *Eumeces okadae* (Hasegawa 1990). It is interesting that the interaction I observed took place

between juveniles of both species. Previous studies have shown that juvenile robins are less skilled when foraging for invertebrates and fruits (Vanderhoff and Eason 2007). Therefore, one might not expect that a juvenile robin would attempt to capture a skink. However, juveniles are often more likely than adults to pursue and consume novel food items (Wunderle 1991).

Juvenile Five-Lined Skinks may also be less skilled at escaping predators than are adults. I did not witness the initial capture of the skink by J1 so I am unsure of any anti-predator behaviors that the skink may have used at that time. However, many species of *Eumeces* flicker their vividly colored tails to distract predators (Cooper 1998), and studies have shown that juveniles that display this behavior are better able to escape from snakes (Cooper and Vitt 1985).

Five-lined Skink populations may be more intermittent and less common in Ontario than in Kentucky where this interaction was observed. In recent years Five-lined Skink populations have been in decline in Canada, and under the Species at Risk Act the Five-lined Skink is listed as a species of special concern (Quirt et al. 2006). Human removal of woody debris has eliminated an important microhabitat for the skink, and the decline in appropriate microhabitat is thought to be one of the main causes for the skink's decline in some areas of Canada (Hecnar and M'Closkey 1998). Woody debris is important for nest sites, but also acts as an important refuge from predators (Hecnar 1994), and removal of these refuges may increase the Five-lined Skinks' encounter rate with avian predators, like the American Robin, as well as increase the skinks' likelihood of being captured.

Birds and lizards are commonly studied organisms, but documentation of predator-prey interactions between these two groups is rare (Blomberg and Shine 2000), although avian predation is thought to be the selective pressure responsible for the vivid blue tail of juvenile skinks (Cooper and Vitt 1985), little information exists on interactions between birds and skinks. Both quantitative and qualitative information on predator-prey interactions between birds and lizards is needed to add to knowledge of both groups.

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Book Reviews

Book Review Editor's Note: From this issue forward we will use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Renmibi are CNY, Australian dollars are AUD, and so on. You will find these are the codes now used by financial institutions and internet currency converters. I will include an updated note for the next few issues as a reminder.

ZOOLOGY

Atlas of Breeding Birds of Ontario 2001 – 2005

By M. D. Cadman, D. A. Sutherland, G. G. Beck, D. Lepage, A. R. Couturier. 2008. Published by Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, Ontario Nature. xxii + 706 pages. 96.00 CAD Cloth.

There's nothing like a good, hefty book to make reading in bed difficult; there's also nothing like a good, hefty book that's full of all the information it's supposed to have. This second atlas of Ontario birds is both. Like all recent atlases, this book has enough coffee-table appeal to be of interest to non-birders, and could in fact, entice them into the fold. This is not at the expense of the data, since the book typically presents the data thoroughly and well. I am very happy that Ontario (as most jurisdictions) chose to publish a book, and not a CD-ROM, as did Oregon…people will always be able to read books…CDs may already be on their way out.

Given that this is a second atlas for Ontario, the opportunity to compare results with the first atlas was there, and was used. The reader can see instantaneously whether 10 × 10 km squares (in southern Ontario) or 100 × 100 km blocks (in northern Ontario) have had a change in breeding status. This segues me to describe the regrettable, but unfortunately practical practice of giving less detail to the north than the south; being a native born-and-raised northern Ontario boy…this has always bothered me, but as stated, I see the practicality. What I don't understand, though, is the situation where the distribution of a bird like the Palm Warbler is shown as six squares on a large, and large scale southern Ontario map, even though the distribution of 99% of the population is shown on a smaller, and smaller scale, northern Ontario map. At least northern Ontario is covered, unlike the otherwise-fantastic Quebec atlas, which didn't attempt to describe birds in the northern two-thirds of that province.

This atlas has several important chapters of preamble, though, like the Alberta atlas, these are essentially limited to what is necessary to best understand the species accounts. Other jurisdictions have provided a greater diversity of introductory chapters to create an even more useful atlas – these include chapters on the local history of birding and ornithology, aboriginals and their relationships with birds, conservation, and others. Although not necessary, chapters like these would have enhanced the Ontario atlas.

Somewhere in the fleet of introductory chapters or appendices, one would have expected to come across a very basic piece of information – the number of squares in Ontario. There are tables in the introductory chapters and appendices which tell you the number of squares in which a species was found…obviously, without knowing the total number of squares, the former information is less valuable than it could be.

As with the Alberta atlas, each species account is given one double-page spread. This is convenient for the reader and allows for enough text, graphs and maps in most cases. It must have been an editorial decision to do this – surely some species could have done with three pages, without getting verbose. However, a two-page allotment does give a decent treatment to all. The accounts are divvied into appropriate subheadings in Distribution and Population Status, Breeding Biology and Abundance. A multitude of authors wrote these species accounts, and even so, I didn't find a single one lacking. All were well, to me extremely well, written – congratulations go to the authors, reviewers and editors of the species accounts. By using the multi-author approach, the workload is spread out and the project takes advantage of the areas in which these folks specialize.

This atlas incorporated point counts into its methodology as an important way to quantify many species. Very intuitive maps show the distribution of different population densities. By doing this, the third atlas will be better able to quantify population changes on the whole, as well as shifts in population centres and borders within Ontario.

In contrast, there are many other surveys from which information could have been incorporated into the atlas; not all species are effectively sampled using point counts. For example, the Ontario Nocturnal Owl Survey data could have been summarized for each of Ontario's owls; this would not have been a daunting task. The Breeding Bird Survey data, along with the

data from other sources, were incorporated into the Oregon BBA, to the overall benefit of atlas users.

There are some technical points to the data presentation that I did not find appealing or useful, though I will only mention the bigger ones here. For each species, there is a histogram which illustrates the probability that a person spending 20 h birding will encounter a species in a square from one of the five biogeographic regions of Ontario (and another bar illustrating the data for all of Ontario). On the y-axis are the labels for the five regions and the whole of Ontario; the x-axis shows the probability. There are two bars for each region, one for the first atlas, one for the second. Having both bars does give the reader a good idea of the change in abundance of the species. However, there are two issues with these histograms. The first is that the exact value of the probability is put at the end of each of the twelve bars...isn't that what the x-axis is for? For those very few people who need to know an exact value (e.g., a 59.9% chance of finding a House Finch in Lake Simcoe-Rideau) instead of the ballpark x-axis value of 60%, those data can be retrieved from the atlas project. For the rest of us, the data labels (made popular by many software packages) are simply so much clutter.

Secondly, regardless of the data, the x-axis is always calibrated in 20% increments, from 0-100%. That means, for species like the Ruddy Duck and Wilson's Phalarope, where eight of the twelve bars are at 1% or less, the reader barely sees the bars...why not scale the axis from 0-10% to show the data more effectively? This becomes ridiculous with birds like the Worm-eating Warbler and Northern Wheatear, which have some of the six categories blank, and *all* of the others with non-existent bars labelled at 0.0%.

Each of the species accounts features one photograph of the bird and sometimes a habitat and nest shot as well. The quality was from good to great... there were a few shots that I would have replaced, but nothing serious here. To increase the visual appeal, I would have included more habitat shots; both *The Birds of British Columbia* and *Birds of the Yukon Territory* had more of this, and I think that added quite a bit to those books [Neither of those books are atlases *per se*, but both do show distribution and breeding records]. A few photographers contributed many of the pictures, though overall there was a good diversity of photographers; that many peoples' works get featured is always good to see in a volunteer effort...so this is definitely a plus in my mind.

Finally, the cover photo. A Prairie Warbler? Really? Why? This bird was recorded in only 45 squares in Ontario — that's less than 0.5% of the total. If I were to ask you to name the best-known bird of the Yukon, what would it be? And yes, it's on the cover of their book. The widely-dispersed Red-tailed Hawk was a fine choice for the cover of the first atlas of Maritime birds. Surely something much more widespread and charismatic like their provincial bird, or one known to almost anyone who feeds birds in Ontario, like the Dark-eyed Junco, would have been more appropriate. The decision to have the very local Prairie Warbler as the coverbird just boggles my mind.

Overall my impression is that this is quite a good book that could have so easily become a great book. Ontario atlassers should be very satisfied with their second atlas – it largely presents the efforts of their long hours well; users of this book will be faced with a lot of information that is well-organized, and pleasing to read.

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The Return of Caribou to Ungava

A. T. Bergerud, Stuart N. Luttich, and Lodewiih Camps. 2007. McGill-Queen's University Press, Montreal, Quebec. 2007. 586 pages. 49.95 CAD Cloth.

This is the most comprehensive book on Caribou ecology and predator-prey relationships that has appeared in many years, perhaps ever. Not only is the research seminal, but the authors systematically dismantle paradigms that have been in vogue for years. According to the authors, Caribou biologists have wasted the last 50 years measuring lichens on winter ranges, when they should have been documenting plant production on summer ranges. Wolves, along with human hunters, both limit and regulate caribou populations, not habitat. Food on the summer range only regulates at high densities and only after the range has been overgrazed. Wolves are driving Woodland and Mountain Caribou to extinction. Caribou populations where Wolves are absent maintain densities 100 times

greater than predated herds. The reason arctic Caribou migrate to barren ground calving areas is to avoid Wolves tied to den sites at treeline. Even so, if it were not for periodic rabies epidemics, migratory Caribou populations would be severely limited by Wolf predation. Volcanic eruptions half a world away trigger population declines in arctic Caribou at high densities. And this is just for starters.

The book chronicles the history of the George River Caribou in Labrador and Quebec from near extinction during the early 1900s to an estimated 600 000 animals before the herd declined. The authors explore the various hypotheses that have been proposed to explain these fluctuations and present data set after data set to separate between competing explanations. In addition, the authors discuss virtually every other Caribou population that has been studied in North America, Scandinavia, and beyond, including the difference between migratory and sedentary herds, which is key to understanding this species' ecology.

To the south of Ungava are small non-migratory populations of Woodland Caribou that are being driven to extinction by Wolf predation. But in reality, Moose and White-tail Deer are to blame. Historically, these areas sustained low-density, widely-spaced Caribou that in and of themselves could support few or no Wolves. Moose and whitetails were absent. But since the early 1900's, Moose and whitetails have extended their range providing alternative prey for Wolves, where none existed before. The Wolves then drive the more vulnerable Caribou ever downward. That is to say, the addition of alternative prey did not buffer predation on Caribou, but instead increased predation pressure, contrary to what many people would expect. But that is not the most intriguing part.

Why were Moose and whitetails absent historically and prehistorically? The authors contend that logging changed coniferous forests to secondary deciduous species favored by Moose and whitetails. In this I believe they erred because fire history data indicate there was always a strong deciduous component in those forests. Besides, Moose and Whitetails can survive on a winter diet of Balsam Fir, as they do on Isle Royale and Anticosti Island. Instead, I believe that native hunters once kept eastern Moose populations in check, as I know native hunters did in western North America, where there are more Moose today than at any time in the last 12 000 years (see *Alces* 33:141-164). Historically and prehistorically, native hunters extirpated Moose over large areas because, like the Wolves discussed above, humans had a multitude of alternative prey, including vegetal resources and fish unavailable to carnivores. As aboriginal hunting pressure declines, prey populations increase. In fact, the authors note that the influenza epidemic of 1918 decimated native populations on Ungava, which in turn allowed Caribou to increase.

I certainly commend the authors for presenting data on aboriginal peoples since the time Ungava was first inhabited and for describing how human hunting impacts Caribou. Most other studies of ungulate ecology begin with the premise that native people are irrelevant because everything was a "wilderness" untouched by the hand of man prior to the arrival of Europeans; e.g., see *The Kruger Experience*. As I have explained elsewhere, however, this is a fatal error. The authors did not make that mistake, but I would suggest they need to look deeper into human evolutionary ecology. Take the seemingly random movements of Caribou, a subject covered at length in this book.

Unfortunately, the authors neglected to consult Binford's data on Inuit Caribou hunters — see *Numamint Ethnoarchaeology*. One of the questions Binford asked was how do caribou hunters select a direction to hunt when they have no prior knowledge of where the Caribou are? The Inuit base their decisions on what we in the West would call mysticism. By careful observation, however, Binford determined that Inuit pre-hunt behavior was simply a random number generator. That is to say, in these cases, the Inuit hunted randomly, which makes perfect ecological sense, odd though it may seem.

If the Caribou moved in a predictable pattern, they would be easy prey for aboriginal hunters, as the authors note when the Ungava herd is forced by topography to cross the George River at Indian House Lake. If the hunters hunted in a predictable pattern, the Caribou would quickly learn to avoid the hunters, and the people would starve. The solution to the Caribou's problem is to move as randomly as possible, while the solution to the hunter's predicament is to hunt randomly. This co-evolution occurred over thousands of years and probably is the only evolutionary stable strategy available to both Caribou and humans and then only because the Caribou's range was vast and diverse. The authors note that even when Ungava Caribou numbered only 15 000 animals, spread over an immense area, aboriginal hunting alone kept the herd from increasing. Using dog sleds, native hunters would follow caribou tracks for days, until the animals were killed or the trail lost.

The *Return of Caribou to Ungava* should be read by everyone with even a passing interest in northern ecology, caribou management, or predator-prey relationships. It should also be read by historians, anthropologists, and archaeologists.

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A Guide to the Mammals of China

Edited by A. Smith and Y. Xie. 2008. Princeton University Press 41, William Street, Princeton, New Jersey USA 08540-5237. 576 pages. 60.00 USD Cloth.

China, like many other areas outside North America and Europe, has had good field guides to the birds for some years. Finally it now has a decent guide to the mammals. Unlike the mammal guides for Africa and South America, this new Chinese book includes a more thorough coverage of the small stuff, such as rodents, pikas, shrews and the like.

It was produced with contributions from nine people from the United States, the United Kingdom, Italy, and China. It is refreshing to see such a cooperative effort by a multi-national team in a region where politics often clash. The book covers all of China, including Taiwan and Xizang [Tibet].

The artwork is by Federico Gemma of Italy and is top quality. I am particularly impressed by the way he has occasionally moved away from the "classic" guide poses. For example, he portrays Tibetan Gazelle leaping through the air. This accentuates the gracefulness of this lovely species. At first it may appear that Gemma has an easy job because so little is known of Chinese mammals in the west. This is not true. We are familiar with the cute poster mammals — the Giant and Red pandas and the Tiger. Many animals are familiar zoo and park species — Muntjac [Red], Sika and Sambar Deer. Others are common species in more accessible places — Ermine, Caribou, Moose, Red Fox. Using these as a guide, the reader will soon see that the illustrations are accurate. If you want to examine the accuracy further, then you can verify details like the facial features of the Greater Horshoe Bat. However, not all of the species are covered by this fine artwork. I estimate that a little over 67% of the 556 species are depicted [although some of the non-illustrated species are in other, readily available, books].

The book has a great introductory section covering geography, the history of mammalogy in China, and conservation. This includes some useful maps and photographs. The text consists of the typical sections on characteristics, distribution, natural history, additional comments, and status. I was pleased to find this information is current and honest. Chinese literature meant for the West often glosses over key problems. This is not the case here, and the status of the Tiger, for example, is clearly stated. The reasons for its decline are given frankly. As this book covers 81 species more than I have on my existing Chinese mammal list, I tried comparing the two. I gave up after about 150 species because there were considerable differences. Many additional species, primarily from the fringe areas of Xinjiang, Xizang and Yunnan, were included and many others were omitted. I realised many of the missing ones had been assigned a new genus name making direct comparison more difficult. I did wonder why the Eastern Black Crested Gibbon (*Nomascus nasutus*) was not mentioned except in a list of subspecies. This is generally regarded as a full species and is considered the most endangered primate. There are a few [in the low tens] on Huinan [plus a similar number in Vietnam]. Other species like the Manchurian Zokor *[Myospalax epsilanus*] and the Chinese Scrub Vole [*Microtus irene*] are not even mentioned, yet are listed in Duff and Lawson's Mammals of the World and other references.

In addition, there are some changed common names — Onager is called a Kulan, for example. Also only five coastal species of marine whales out of over two dozen pelagic species are included. [However an Appendix lists an additional 29 cetaceans]. Yet all five possible seals recorded, mostly as vagrants, on China's coast are in the book. Another problem is characterized by the distribution of the Northern Birch Mouse, *Sicista betulina*, given by some authorities as being in China, but others as being absent [Including this book]. I think that all of these differences reveal the status of the taxonomy of Chinese mammals and the need to increase research. I will now use this book as the authoritative list, but will likely still consider fringe species.

The issue I have with the text is in the "characteristics" sections. The descriptions will be difficult to use in the field as there is very little comparison with like species. The descriptions are generic enough to overlap and the illustrations are similar. For example, Jerboas are very difficult to separate. I know how hard it is to see these small fast creatures [the Great Jerboa goes over 40 km/hr!] in the field. There is a key to each genus, but this is more useful for museum specimens. [In fact there were a few places where I felt strong museum overtones as opposed to field experience. However, the book is not called a *field* guide.]

In addition to re-assigning genera, the authors have split the Eurasian Moose or Elk from the North American Moose. In China there are two widely separated populations: one in Xinjiang [north west] and one in Heilongjiang [north east]. They have made this split based on the larger size, redder fur and bigger dewlap of the "American" Moose. No other reference makes this difference.

The range maps plot actual museum and other records rather than shaded estimations of current distribution. This is more precise and factual, but may not represent today's status and may be more of a historical record. This will mean the reader will have to interpret the data carefully so as not to get a wrong impression.

I did spot a couple of errors. Savi's Pipistrelle's range is given as Xinjiang ... to Northern Europe. It actually is found in Greece, Italy and eastern Spain, not what I consider northern Europe. The index indicates that the Tibetan Antelope is on Plate 60 when it is depicted on Plate 57. I also question the range map of the Spotted Seal, shown with many specimens going

far inland. I would be surprised if this pack-ice loving beast would go up fresh water rivers.

Notwithstanding my comments, this is a much-needed guide and it will be indispensable for naturalists and mammalogists for years to come.

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Birds of the Saskatoon Area

Edited by Anna L. Leighton, Jim Hay, C. Stuart Houston, J. Frank Roy, and Stan Shadick. 2002. Nature Saskatchewan Special Publication Number 23, Regina and Saskatoon Nature Society, Saskatoon. 345 pages. 40.00 CAD [30.00 CAD to Saskatoon Nature Society members] Paper.

During my second encounter with the late J. Bernard Gollop in Regina some time between 1968 and 1970, the late Margaret Belcher and her sister, Mary Houston, mentioned that his planned book on the birds of the Saskatoon area would probably be the next of the esteemed Saskatchewan Natural History Society special publications to appear. Unfortunately, Bernie did not live to see it in print, but 77 authors and six editors finally brought his 1965-1988 efforts to fruition. The long gestation period produced an outstanding addition to Saskatchewan's ornithological literature.

This largest book in the series to date is also the first to be co-published [by the Saskatoon Nature Society] and is the fifth in the Manley Callin series on birds of specific areas of the province. It is jammed with information, with even the covers and fold-outs from the covers containing information [an area map, a Landsat image of the study area and a few tables]. Introductory material covers the first 68 pages of text, including publication blurbs, tables of contents, drawings, maps and photographs, a dedication to Bernie Gollop, a preface, a foreword by Farley Mowat, a poem, acknowledgments, chapters on birding aids, histories of birding in the area and of the project, a detailed chapter on habitats and other ecological influences on the local avifauna, a detailed chapter on "hot spots" [essentially a bird-finding guide], a list of "unpublished" sources [including published seasonal compilations] consulted, a list of abbreviations, a topography and a glossary. These are well illustrated with figures, maps and drawings. The bulk of the text consists of 340 species accounts in taxonomic order except for one [Prairie Warbler] that was added while the book was in late stages of production. Eight appendices, a list of references cited and indices to English and French bird names close the book.

The species accounts are preceded by a two-page introduction, explaining their contents and definitions used for seasonal occurrence, status in the area, abundance, tables of arrival and departure dates and other general information. Species accounts range in length from two paragraphs to two and a quarter pages, depending on regularity of occurrence in the area, amount of knowledge of the species' life history features in the area, numbers banded in the area, and other factors, such as change in status, locally, provincially, and/or generally. If migratory, earliest and median spring arrival and latest and median fall departure dates are included. If banded, numbers of the species banded in the area are listed, as are numbers (if any) recovered inside and/or outside the Saskatoon bird area. If known to nest, data are included on whatever details of nesting biology, chronology, habitat and/or success are available. Remarks on population changes and their believed causes are also included if appropriate. Drawings accompany several species accounts. Current English, French and scientific names and one or more four-letter species code(s) are indicated for each species. Former English names are also indicated for several. Nineteen nesting species are listed as hosts of Brown-headed Cowbird documented in the Saskatoon area in both the cowbird and the host species accounts. Several miscellaneous observations of biological, historical or population trend interest are also mentioned, often in a "side bar" or box.

The book ends with a series of eight appendices (on annual Christmas, May Day and fall counts, local Breeding Bird Surveys, numbers of each of 79 species banded in the area, numbers of birds banded by each bander who has banded in the area, nest-box dimensions and requirements for 12 species and a list of 12 theses based on birds studied within the area), a list of references cited and indices in English and French to the first page of each species account.

This volume continues the trend of improving on the already high quality of earlier contributions in this series, using as many sources of published and unpublished sources as possible. Although some variability in style is inevitable in a book with so many authors and editors, the quality of writing and accuracy of information are high throughout. I noted a few minor grammatical deviations, but few errors or omissions of substance. The statement (page 284) that Dickcissels "continue to breed" in southern Manitoba implies regular occurrence there. While they occasionally nest there, rarely in fairly large numbers, their occurrence is irregular, often with several years between sightings (Davis et al. 2003). Minor errors include the omission of the hyphen from screech-owl (page 68), reference to Townsend's Solitaires as "thrush-sized" (page 232), implying that they are not thrushes and a few instances of species names in lower case. The vocalization of Baltimore Oriole referred as a "call" (page 291) ap-

pears to be the song. Cross-referencing between species accounts is quite thorough, but the list of 19 known local cowbird host species (page 290) omits Hermit Thrush (page 235) and Common Yellowthroat records (page 259). Also, a record of House Sparrows nesting in Bank Swallow holes is mentioned in the swallow account, but not in that of the sparrow and a case of hybridization between Eastern and Mountain bluebirds is mentioned only in the Eastern species account. Odd omissions from the glossary are the terms "albinism" and "leucism," especially since the less common "melanism" is included. An odd feature, though not an error, is the use of U.S. spelling for behaviour, centered, colour, favoured, harbour, moulting, neighbourhood and variants of these. The difference in slope of the bill between Tundra and Trumpeter swans, a feature much easier to see than the visual differences noted, would have been a useful addition to the identification tips in the swan accounts (pages 89 and 90). The header for Wilson's Snipe indicates that two nesting records have been documented in the area, whereas three are mentioned in the text. The record of a robin feeding a young cowbird (page 237), while interesting, is not definitive evidence of successful parasitism by cowbirds on robins, as non-parental birds sometimes feed offspring of birds of other species (for example, Salt 1997). Most references cited are included in the reference list, but one by Allen (1952) is cited as both Allan [incorrectly] and Allen on page 138, one by Dunn et al. (2000) cited on page 189 is not listed unless 2002 is intended, the title is missing from a paper by Greenberg and Droege, the pages of the 1996 owl paper by C. S. Houston should be 125-133 [not 25-132] and the second author of the book by Robbins et al. should be B. Bruun, not B. Brown.

Although such regional works serve primarily to document occurrence, dynamics and changes in local bird populations, they also serve to document various life history observations that the author(s) may otherwise never find time to write up. Examples of such tid-bits in this book include fondness of Snow Geese for peas, television tower casualties of Green-winged Teal, albino and/or "partial albino" Ruddy Duck, magpies, Mountain Bluebird, Yellow-rumped Warbler and Yellow-headed Blackbird, a pair of Red-necked Grebes incubating golf balls, predation by American Crows on Eared Grebe eggs, cormorants perching on power lines, a dry land nest of an American Bittern, Willet courtship flight, magpies chasing and catching bats and eating berries, a Bank Swallow colony in a hole in a wheat field, House Sparrows nesting in Bank Swallow holes, robins nesting on antlers and large numbers of starlings flycatching.

Another measure of success in such regional works is the degree to which they stimulate publication to fill in gaps and document changes. Judging by the number of notes and papers on bird observations and research in the Saskatoon area that have appeared in ornithological and natural history journals since "Birds of the Saskatoon Area" appeared in print, this volume has succeeded in that respect as well. It is an important contribution towards a forthcoming two-volume account of the birds of Saskatchewan.

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Book Review Editor's note: In a brainstorming session between the Editor, Francis Cook and myself, on future directions, we agreed I would investigate suitable websites and, if appropriate, include their reviews. I proposed we use Brian Coad's site as a test case, hence the following review. If others know of similar suitable sites [Cornel University, USDA and USGS come to mind] please e-mail me [r.john@ rogers.com] with your suggestions.

Brian Coad's Ichthyology Site

http://www.briancoad.com/main.asp?page=fishdictionary.htm
By Brian Coad. 2008.

Unlike books, websites are not static. This is the case with Coad's site, which is defined as a work in progress. What it currently contains is sections on Projects, Fishes of Canada: Annotated Checklist, Dictionary of Ichthyology, Freshwater Fishes of Iran, Fishes of Canada's National Capital Region and Freshwater Fishes of Iran.

The first section lists the author's eight current projects, with a few sentences of explanation. The checklist of Canadian Fish is a straightforward list of scientific and common names in both languages, plus occasionally a few comments. The dictionary, co-authored by the late Don E. McAllister, defines terms specifically used in the study of fish and includes some generally used common words.

The Freshwater Fishes of Iran has individual species accounts arranged by genera. These start with an introduction to the genus. Each detailed account has sections on the Common name in English and Farsi with the phonetic pronunciation, Systematics, Key characters, Morphology, Sexual dimorphism, Colour Size, Distribution, Zoogeography, Habitat, Age and growth, Food, Reproduction, Parasites and predators, Economic importance, Conservation, Further work and Sources.

These accounts are illustrated [black-and-white line drawings] and give the reader a very exhaustive understanding of the individual species.

Fishes of Canada's National Capital Region [NCR] has similar coverage to the above. Also included are photographs of out-of-water fish where these are available and range maps within the National Capital Region. I decided to try out the site to identify small fish I saw in Mud Lake in Ottawa. After comparing descriptions and other information I decided it might be a Central Mudminnow. To be certain I would need the fish in hand. I might raise eyebrows, or worse, if I started netting fish in a public park.

The Freshwater Fishes of Iraq contains only a checklist and bibliography at this date.

Some of the advantage that this web site [and all others] have is that material [such as photos] can be included as required, poor quality photos can be replaced if better become available, multiple photo can shows all features (not the case in a book where cost and space are limitations), text and other errors can be corrected, feedback from readers is easily incorporated, new information can be added as science progresses, in some cases differing view points can be presented at length, saving on costs of paper and distribution over the book format. The site can be accessed from anywhere in the world [with Internet access] without needing to carry around hard copy, it is copied by students, researchers and naturalist for their own projects

This site is a wonderful source of information in a subject area that is often difficult to access. It is very easy to navigate and loads quickly [but it is not as user-friendly as a book]. I am not one to load up my favourites folder unless it is a site I will use frequently. I suggest this is one of those sites, especially if you live in the Ottawa-Gatineau area (National Capital Region). I also need to trust the information supplied. The generic question remains in that sites like this have not been reviewed as a book would be. Readers on the internet will need to verify the quality of a website before trusting the data. As Brian Coad is a respected research scientist (at the Canadian Museum of Nature) with extensive field experience in the Ottawa District and Iran, this is not an issue, despite its being a personal, rather than an institutional site. At least you should take a look at it as I am sure you will learn as I did.

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BOTANY

Exploitation and Utilization of Chinese Spice Plant Resources

By Zhang Weiming and Xiao Zhengchun et al. 2007. Southeast University Press. 722 pages. Price 186.00 CNY.

Spice plants are in a special category in the plant kingdom, and have been popularly used for various purposes in different countries or regions of the world. The history of the use of spice has even exceeded recorded history of human beings. Early humans might have used spice plants to preserve meat, fish or other food, reduce the annoying odors of various foods, or increase a special flavor when cooking. Gradually, these began to expand the range of use of spice plants.

Spice plants are closely related to the daily lives of human beings. Systematic research and summary of them is necessary, however, as this has not been well done before, at least in China. Now, this situation has been changed by the publication of the book *Exploitation and Utilization of Chinese Spice Plant Resources* by Zhang Weiming and Xiao Zhengchun et al. The authors have been engaged in research work on spice plant resources for a long time. They have conducted several research projects relating to Chinese spice plants in the last few decades, and obtained valuable and abundant data in this field. Meanwhile, they also collected other abundant information on spice plant resources at home and abroad. Based on these data and information, they produced this massive book.

There are a number of climate zones in China. Different environmental conditions allow for the growth of an abundance of plant species, including spice plants. Except for a few tropical species, most of the spice plants grow in China. China was one of the earliest countries to use spices. There are some records on the aromatic and spicy plants in the Book of Songs, the Book of Mountains and Seas, and other book that are more than 2000 years old. Over a long time, due to the various usage of different types of spice plants in cooking, the people living in various areas of China formed a variety of eating habits, reflected in the so-called eight genres of cuisine of Chinese dishes. Hence, we might say that one of the most important reasons that Chinese food (or any other regional food) enjoys a world-wide reputation is its unique use of spices in cooking.

The indigeneous spice plants in China are abundant. Furthermore, over the years, China introduced many foreign-origin species. The book not only is a systematic and comprehensive monograph on the spice plant resources of China, but also has its value as a reference for other related countries. The book is divided into two parts. The first part is a general introduction to spice plants, including the history of spice plants, the general situation of Chinese spice plant resources, the main ingredients and the application of spice plants,

the processing technology and the development of spice plants, and the strategy of the development of China spice plant resources. The second part is the special issues, including a total of 134 kinds of commonly used spices, and more than 200 spice plant species. For each spice plant species, the ecological environment, history of use, chemical ingredients, comprehensive methods of use, exploitation of related products, standardization and cultivation techniques, and so on were comprehensively introduced. The typically introduced spice plant species in this part include *Capsicum frutescens*, *Allium sativum*, *Aglaia adorata*, *Allium cepa*, *Allium fistulosum*, *Allium porrum*, *Allium sativum*, *Artemisia vulgaris*, *Illicium verum*, *Foeniculum vulgare*, *Levisticum officinale*, *Mentha haplocalyx*, *Pimpinella anisum*, *Sesamum indicum*, *Zanthoxylum bungeanum*, *Zanthoxylum simulans*, and *Zingiber officinale*, among others.

The book was well written with few errors, in a style of writing that can be easily understood by non-scientists. As a comprehensive book, it is suitable for anyone who is engaged in the various areas of research and application of spice plants.

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MISCELLANEOUS

Arctic Hell Ship

By W. Barr. 2007. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1. 318 pages, 34.95 CAD Cloth.

More of a human history than a natural history book, this tale covers part of one of the great sagas of Canada's north. The Franklin Expedition left Britain with high hopes and the best resources available — well almost. It vanished in 1845 and spawned at least two dozen searches to solve the mystery of the disappearance. These efforts in turn have led to a flood of books and scholarly articles.

So do we need another treatise? The answer is yes in this case. Barr's contribution covers the 12th search by Captain R. Collinson aboard the *HMS Enterprise* with Robert John Le Mesurier M'Clure, as second in command, on the *HMS Investigator*. Barr gives us an extremely detailed description of life on one of Her Majesty's ships in the 1800s. So often the other books concentrate on the leaders and their accomplishments, so we learn little of how the crew fares. Barr remedies this by telling us about many of the individual sailors. The "story" is very simple. This was a voyage that produced limited results and suffered a lot of bickering between the officers. As a result, the ship's, logs and letters contain irritating daily details that show what life was really like.

Collinson was a good seaman and surveyor, but he was clearly not a leader. He picked on very minor transgressions and turned them into major disciplinary actions. He sowed unnecessary seeds of discord, interspersed by bouts of humanity. In hindsight, his biggest failure was that he did not do enough. He was charged with rescuing Franklin's men and given the resources to do it, and yet he spent a lot of time sailing back and forth, unable to make a clear decision. His sledging trips were too little and too late. The other ships in his command (which got "separated" early in the expedition) went farther and did more. When Collinson did make progress he found notes from either M'Clure or Dr. John Rae showing that they had searched the area earlier. In the tough conditions on board ship during an Arctic winter this debilitating caution and indecisiveness coupled with petty decisions on discipline must have made an unhappy ship full of exasperated people.

Collinson returned to Britain, having failed to solve the Franklin issue, demanding courts-martial for his officers. The lords of the Admiralty wisely declined to take action. Public exposure of such silly shenanigans would do the service no good.

The most notorious British naval captain of this era is Bligh. In spite of the fact that his reputation owes more to the movies than reality, Bligh was a superb navigator, excellent seaman and a relatively humane captain. He personally intervened in the trials of the captured mutineers, got some set free and obtained reduced sentences for others. He died as a Vice-Admiral. Collinson's dithering and his stubborn need for absolute discipline would have made him a better candidate for Hollywood's spite, yet even this would be unfair. How would we all fare under such harsh conditions?

Collinson did make Vice-Admiral, after serving at Trinity House, the establishment that maintained the aids to navigation, where he rose to deputy master. He remained at Trinity House until retirement, clearly a better bureaucrat than expedition leader. Perhaps the error lies with the lords of the Admiralty. They fell into that awful trap. They promoted a very technically competent person to a supervisor, a move that does not always work. In particular, voyages to the Arctic, even today, need competent leaders. Collinson did not come close to Nansen, Shackleton, Amundsen, or even Scott in his ability to deal with people.

While Barr has produced a minutely detailed document, using all available evidence, rather than a dis-

tillation of the key events, it is those details that give the book its appeal. I found I wanted to read just one more paragraph each time before I put the book down. I was surprised when I realized I was over half way through the book and it seemed I had just started. As I stated initially this is really a history text, but it covers a key era in the story of Canada. The only important note of natural history concerns the surgeon, Edward Adams, for whom the Yellow-billed Loon was named *Gavia adamsii*. It is well worth the read if you love the Arctic, enjoy history or are a Franklin buff

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Eighteenth-century Naturalists of Hudson Bay

By Stuart Houston, Tim Ball and Mary Houston. 2003. McGill-Queen's University Press, 3430 McTavish Street, Montreal, Quebec, H3A 1X9. xxiv + 333 pages 49.95 CAD Cloth.

In 1959, C. Stuart Houston and Maurice G. Street began to introduce prairie naturalists to the pioneering contributions of employees and other associates of the Hudson's Bay Company and to expand our understanding of the natural history of Canada's Arctic and prairie regions (Houston and Street 1959) in the first of a long series of articles, books, notes and papers by Houston and numerous colleagues on biographies of specific contributors and the history of various aspects of these contributions. In this volume, Stuart and his chief collaborator (Mary I. Houston) bring many of the details of their earlier publications together, expand on the European collaborators of these naturalists and compare the Hudson's Bay contributions with approximately contemporary efforts in South Carolina. They also collaborate with Timothy E. Ball in outlining the contributions of H.B.C. officials in documenting climatological details at various sites and their changes over a long time period and with Arok Wolvengrey and Jean Okimasis in documenting Cree names for numerous natural history species in the lands of the vast territory formerly controlled by H.B.C.

The book opens with a series of introductory sections, including a list of McGill-Queen's "Native and Northern Series" (of which this is the 34th), a dedication to William B. Ewart (whose efforts led to the moving of the extensive Hudson's Bay Company archives from England to Winnipeg), lists of contents, illustrations and tables, eight colour plates of birds originally published in two of four 1743-1751 volumes by George Edwards, acknowledgments, a list of supplementary documents available through the internet, a list of abbreviations and a foreword by the Keeper of the Hudson's Bay Archives, Judith Hudson Beattie. The main text of the book (pages 1-142) consists of an unnumbered introductory chapter, followed by 12 numbered chapters. Seven appendices occupy almost as many pages (pages 143-251). About 40 pages of footnotes, 25 pages of references and a 14-page index close the book.

The main text starts with a short outline of the history of Hudson's Bay Company activities in North America and the role of HBC officials in documening natural history features of much of the prairie provinces, Ontario, Quebec, Nunavut and adjacent areas in collaboration with native North Americans and European scientists. The first numbered chapter consists of brief biographies of seven European scientists who received and/or examined animal specimens collected by HBC personnel, described and often named them, and wrote the first accounts of their behaviour and other natural history features. The role of these specimens in developing Linnaeus's system of classification of plants and animals is outlined. Eight chapters follow on the contributions and efforts by eight specific HBC officials (Peter Fidler, Andrew Graham, Samuel Hearne, Thomas Hutchins, James Isham, Alexander Light, Humphrey Marten and Moses Norton). The tenth numbered chapter summarizes these contributions, lists Hudson Bay area bird species mentioned in ten early manuscripts, provides several background details and notes several corrections and omissions in earlier publications. The eleventh chapter, based primarily on four years of archival research by Ball, outlines weather, climate and climatic changes in the area, as documented through records of 30 or more years at 30 HBC posts. The final chapter outlines early contributions to North American natural history by early settlers of Charles Town, South Carolina, when that area was still a British colony. Brief biographies of two contributors of meteorological data and two natural history collectors are included, as well as a list of species named as new in Mark Catesby's 1729-1747 two-volume treatise on the birds of South Carolina (58 from "South Carolina," seven from other parts of eastern U.S. states, seven from the Caribbean, and one from "Quebec."

Seven appendices cover about 100 pages. The longest (about 50 pages) by the Houstons, Jean Okimasis and Arok Wolvengrey lists words used in the eighteenth century in four Cree dialects for various taxa that live in the territory controlled by the Hudson's Bay Company. Another lists departure and arrival dates and the captains of ships sailing between York Factory and Europe from 1716 to 1892.

Smiles will cross the faces of Saskatchewan naturalists, long aware that two of their most prominent members (Margaret Belcher and Mary Houston) were sisters, when they read that one of two ships captained by a Belcher (twice) was "Mary." A two-page appendix by Deirdre Simmons outlines the history of the Hudson's Bay Company Archives. Others concern ten man-

uscripts that have variously been attributed to Andrew Graham and Thomas Hutchins, and plagiarism of Graham by Hutchins. The Houstons provide an interesting account of their research in the archives, in London and at a symposium in the Orkney Islands that brought them to the conclusion that these manuscripts resulted from collaboration. Other appendices concern the ten-year cycles of various northern birds and mammals, the effects of nineteenth century trade on Trumpeter Swans, and the naming of Canada Goose prior to the official existence of Canada. I assumed that the latter was a combined reprint of two earlier publications in *Blue Jay* (Houston 1994, 1995), but some of it presents additional findings of historical research that was stimulated by the earlier notes.

Naturalists interested in historical aspects of nature study will find plenty of interest in this volume. It is written well and researched thoroughly. I found no substantial errors, although a few references cited were either not included in the literature lists or the publication dates and/or author list in the text differed slightly from those in the literature list. One reference (Ross 1834) is listed in a footnote (page 256), but not in the references. Three references cited are not included in the literature list (Gmelin [1788 on page 140], McIntyre and Houston [1999] on page 269) and Rousseau [1969] on page 279, although enough information on the latter is included to enable a reader to track it down). The 1983 book by Peck and James should be listed as Volume 1. Footnote 39 on page 255 on William Wales should refer to Chapter 11, not 12. References to Appendix E and Figure 3.13 on page 52 apply to Appendix F and Figure 3.14; respectively. The abbreviated forms of the authors' names from the more usual versions that they use in publications (Timothy E. Ball, C. Stuart Houston and Mary I. Houston) provides potential confusion for bibliographers who may think that other, presumably related, authors are involved, especially as their usual publication versions are used in some appendices. As noted by Meyer (2004), some of the appendices would be more appropriate within the main text. Although the literature list is substantial, readers new to the subject who wished to follow up with further reading would have benefited from inclusion of more of Houston's previous biographies, book chapters, notes and papers on some of the subjects covered. Similarly, although biographical references are included for many people, none are included for a few (for example, William Rowan) for whom several are available. None of these criticisms detract substantially from the overall high quality of this excellent contribution to the history of nature study in North America.

Literature Cited

Houston, C. S. 1994. How did the Canada Goose get its name before there was a Canada? Blue Jay 52: 141-143.

Houston, C. S. 1995. Earlier use of the name Canada Goose. Blue Jay 53: 116-117.

Houston, C. S. and **M. G. Street.** 1959. The birds of the Saskatchewan River Carlton to Cumberland. Saskatchewan Natural History Society Special Publication Number 2, Regina.

Meyer, D. 2004. [Review of] Eighteenth-century naturalists of Hudson Bay. Blue Jay 62: 120-122.

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Hunters at the Margin: Native People and Wildlife Conservation in the Northwest Territories

By John Sandlos. UBC Press, 2029 West Mall, Vancouver, British Columbia V6T 1Z2. 360 pages, 85.00 CAD Cloth, 39.95 CAD Paper

Professor Sandlos has written a very well-researched text on three major conservation issues. He examines the plight of the Bison, Muskox and Caribou in Canada's north. The author has examined the questions raised about hunting of these three key species and the development and enforcement of laws relating to them. He has done this with a very sympathetic attitude towards Canada's original inhabitants. He compares the lifestyle and requirements of aboriginals to the efforts of Ottawa's bureaucrats to control hunting and to conserve these mammals. These two philosophies are rarely compatible, and this leads to conflict.

I had a hard time reading this book. While I understand the author's sympathy with Canada's aboriginal people I found his constant innuendo very galling. When discussing the native viewpoint he writes without emphasis. When writing about the non-native people's actions he frequently uses parentheses, causing the reader to doubt the adjective's veracity. When defending the native people Sandlos ignores much pertinent information. He proposes the natives are not the wanton killers portrayed by white policemen, wardens and travelers, but long before the arrival of the white man the natives hunted Mammoths, Giant Sloths and others to extinction. This was also before climate change pushed these creatures over the edge [as in Europe]. The latest book on Caribou (Bergerud et al. 2007) notes that after an influenza epidemic decimated native populations, Caribou increased [see review this issue]. In my own experience, two years ago at Cambridge Bay, I was informed the hunting ban on Muskox had been lifted a few months earlier and the town's residents had shot the entire local herd. I had to travel out of town for an hour by truck and an hour and a half on foot to see distant Muskox on this island.

Before the arrival of whites, there were few natives in the north; it was too hostile a climate. Living was easier on the plains with its abundant Bison. In fact the author provides evidence for this concept when he quotes a convicted poacher, Joseph Wakwan, as preferring to hunt the larger Bison over the legal Moose.

The natives moved north after they found they could make money for guns and supplies by trapping Beaver. The demand for Beaver hats was purely European.

I do not know if the author has been involved in creating laws, but I suspect not. This a long and complex process where nobody wins everything they want. At the conclusion you achieve compromise regulations that all can accept, more or less. To constantly criticize the Ottawa law-making bureaucrats, who were trying their best with the information and attitudes of the day, is a futile process. Trying to judge past events with today's understanding is fun, but useless. National committees have learned long ago not to react too quickly to the latest reports and studies. It takes time and careful study to be certain any new data are valid. There have been many reports that claimed something was bad, only to be followed by another that said it was good. We do not want our laws flip-flopping with every new announcement.

If we applied Sandlos's logic that white man's laws do not match aboriginal situations and therefore really do not apply, then I could ignore the laws of England as I am Welsh, a true English aboriginal. [The Welsh inhabited all of Britain before they were conquered by the Angles and Saxons. These in turn were reduced to serfdom by the Norman French.] I, like all those in England, have to obey today's laws. Such is history. The Canadian native people actually fared reasonably well for a conquered community. Compare their fate to that of the Inca after the arrival of the Spanish or the original inhabitants of the Amazon after the Portuguese took over. The arrival of the white man brought white-man's laws, as well as welfare, modern medicine and current technologies. Whether these are good or bad is a moot question. When I wrote my last report on people of the north, the data sets I accessed on diet used by northern residents showed that a high proportion of junk food had replaced food gathered from the wild. In my view, this represents a poor choice; on the other hand, I do not recall any native village starving or freezing to death [as happened in the past, before the arrival of the white man]. We need to remember we all live in today's conditions, which includes a plethora of laws which we must all obey [Whether we agree with them or not. Ask me about CITES. A well-meaning idea, whose concept I support. In practice it is often counterproductive to conservation and frequently punishes those who are promoting conservation.]

Do not let my criticisms put you off reading this book. There is a lot of useful and thought provoking material embedded in the text. The questions and issues surrounding the native people and wildlife in the north are not easy to deal with and I doubt there will ever be "an" answer. This book makes a significant contribution to the continuing research and debate required to make rational decisions. I just wish it was written in a more balanced and critical style.

Literature Cited

Bergerud, A. T., Stuart N. Luttich, and **Lodewiih Camps.** 2007. The Return of Caribou to Ungava. McGill-Queen's University Press, Montreal, Quebec.

ROY JOHN

2193 Emard Crescent, Ottawa, Ontario K1J 6K5

The Ornithologist's Dictionary

By Johannes Erritzoe, Kaj Kampp, Kevin Winker and Clifford B. Frith. 2007. Lynx Edicions, Montseny, 8, 08193 Bellaterra, Barcelona, Spain. 290 pages, 19 EUR Paper.

This is a great little book that will be handy for all who study birds. I can easily slip out of my depth when reading a book or article because I do not understand some terms. Typically I stick a mark in the page and later go to my computer for help. Google searches are normally wonderful ways to fill in your knowledge gaps. But this also disrupts the continuity of your reading and lowers the value you can pull from the text. Having a resource that can sit by your side is a big advantage.

So how accurate and comprehensive is the text? First, let me say the authors use the English spellings [colour etc.] This does not mean a European bias as there are plenty of references to purely North American terms [National Audubon, AOU etc.] and the U.S. spellings are included [spishing vs pishing!]. I looked up several definitions of words which are frequently misused and could only find one significant error. Parameter is not "any variable" but a *constant* in an equation that varies in other equations of the same general form [the classic example is the force of gravity — always constant in Ottawa but different yet constant in Banff.] This is an incredibly common error, even among scientists who should know better. I have a few other less significant comments, such as the needless use of *inter*relationship [relationship is fine, particularly in a dictionary] and I would not say the use of "mirrors" for the white tip of a gull's wing is *uncommon* as it is used in most of my books. I thought, too, that the authors could have included newer terms like sahel [note the lower case s] — A region having characteristics of a savanna or a steppe and bordering on a desert — as well as the classic definition of Sahel — a transition zone between the Sahara and the tropical forests to the south.

Each letter of the alphabet starts with a neat black-and-white drawing of a bird. These are not identified, but I could easily determine the species in all but X and Y. Also I could not find the identity of the artist.

Several pages in my original copy were greyed. As this is totally unlike the publisher, Lynx Edicions, who

normally produce beautiful, crystal clear copies, I contacted them. It appears this was an isolated incident; however, you should check the particular copy you intend to buy. Lynx sent me another, perfect copy.

This will be of greatest use to non-professional avid birders who lack formal training. You can quickly resolve the occurrence of melanin, the nature of remiges, the difference between granivorous and graminivorous, mimesis and mimicry and other sources of confusion. This book would have rapidly ended my last bird-term argument — the meaning of leucism — if I had had it handy. It may not be as valuable to professionals, but I think they will likely find it useful too. Buy this one for yourself!

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Pioneering Women in Plant Pathology

Edited by Jean Beagle Ristaino. 2008. The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota, U.S.A. 339 pages. 89.00 USD Cloth.

As seen by one woman, an M.Sc. graduate in plant pathology from the mid-1970s, it would appear that women scientists in this field are rapidly proving their abilities to shine with accomplishment in what was once an all male profession; moving from being seen as pretty women hobbyists picking wild flowers to serious taxonomists of vascular and non-vascular plants, many of which are plant pathogens. Agriculture has itself moved from its primitive beginnings of slash and burn to a precise science of food production in the 21st century.

As the possibility that a woman may progress from a mere technician and housekeeper of the laboratory to the more stellar role of research scientist has improved, their research results have proved their abilities. The first woman plant pathologist, hired by the United States Department of Agriculture, was Effie A. Southworth, in 1887. Her most significant contribution was the description of the pathogen *Colletotrichum gossypii*, the cause of anthrocnose on cotton, and the recommendation of measures of control of this disease. In 1895, Flora W. Patterson became the first woman mycologist at United States Department of Agriculture. She is remembered for the development of the U.S. National Fungus Collections, which are still of importance to mycologists and plant pathologists today. She also was very involved with the inspection of imported materials for invasive fungal pathogens, and intercepted the dangerous potato wart disease before it was imported into the United States for the first time. Another woman of importance was Edna Marie Buhrer, who brought forward the importance of nematodes in plant diseases; up till 1920 the role of nematodes in crop production was considered unimportant. This led to various treatments of soils with nematicides which results in improved crop production.

In England also the importance of women in this field was recognized at Rothamsted Research Center and among those employed there and making a valuable contribution was Mary Gwynne. She started her career in 1917, worked mainly on diseases of cereal crops, and in 1960 was awarded the Order of the British Empire for her contribution. Margaret Newton, at MacDonald College, McGill University, was a Canadian woman who made a considerable contribution to the knowledge of stem rusts of wheat, so important to the agricultural economy of Canada. At this period of time in the early twentieth century, women from European countries were also making their contributions.

It is recommended that this book be on the shelves of every plant pathology department library, not only to show the valuable contributions made by these scientists, but also to show the courage and dedication of these pioneering women in the face of the prejudices of those times. This book also highlights the importance of this field of science to the agriculture of the American continent and the safety of the world's food trade. We have here a book about pioneering women plant pathologists who have overcome prejudice to make considerable contributions to the economy of North America.

Pioneering Women Plant Pathologists is edited by Jean Beagle Ristaino; and the careers of 26 women scientists are outlined by 37 authors from the United Kingdom, United States of America, Canada, Portugal, Italy and the Netherlands. It is most interesting to read, and gives one a very good indication of what these plant pathologists have contributed to this field.

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Birdwatcher: The Life of Roger Tory Peterson

By Elizabeth J. Rosenthal. 2008. The Lyons Press, Guilford, Connecticut. 437 pages. 34.95 CAD.

Roger Tory Peterson's parents could not afford to send him to college and he had no formal training in science. He moved to New York City, where he painted designs on furniture in the mornings to earn enough to attend art classes in the afternoon. He joined the Bronx County Bird Club, following the new concept of identifying birds in the field without the need to shoot any specimens for confirmation. The club's pres-

ident, Ludlow Griscom, was an early advocate of this method and RTP soon rivaled him in auditory and visual skills.

RTP's first book, *A Field Guide to the Birds*, published 27 April 1934 at the height of the depression, made bird identification easy for the first time. His wide-ranging combination of skills and knowledge made possible the succeeding Peterson field guides, all published by Houghton Mifflin in Boston. Each used the "Peterson system of field identification," with an arrow pointing to important field marks for each species. Millions of copies were sold. His first bird field guide went through four more revisions, the last posthumously; it was 85% complete when he died a month before his 88th birthday. Through his multifaceted achievements: books, articles, photographs, movies and paintings, Peterson became the best-known and arguably the best-loved naturalist in the world.

RTP's first teaching experiences were at a boy's camp in Maine, and in writing pamphlets for members of Junior Audubon Societies. He remained a teacher all his life. His dedicated second wife, Barbara, managed his home and business affairs with great distinction, freeing him for extensive world travel.

Liz Rosenthal's informative book is based largely on 147 interviews with 117 people, including many of the "who's who" of the birding world. Their words and memories provide inside stories about their interactions with Roger. The inevitable result of this methodology is a few minor omissions. As one example, Rosenthal's book omits one of RTP's early pupils at the Rivers School near Boston: Eliot Richardson, who much later became U.S. Attorney-General and successfully nominated RTP as the teacher who had influenced him most, resulting in the nationwide "Teacher of the Year" Award. Nor we do we learn that RTP's final total of honorary doctorate degrees reached 23.

Conservation themes are interwoven throughout this book. These began with Peterson's long involvement with the National Audubon Society, as a director, secretary, columnist in their magazine, and presenter of some of their most popular screen tours. He helped found the World Wildlife Fund, helped save fragile areas such as the fabulous Coto Doñana in Spain, Midway Atoll in the Pacific and Aldabra Atoll in the Indian Ocean, and helped Kenya's Lake Nakuru become a national park, where a million flamingos form "the world's greatest ornithological spectacle." He photographed all 17 of the world's species of penguin.

We learn of Peterson's close friendships with two other world-famous ornithologists, James Fisher and Sir Peter Scott. As evidence of his stature among professional ornithologists, Peterson served as president of the Wilson Ornithological Society and as Vice-President of the American Ornithologists' Union (AOU). An icon, he received the William Brewster Award from the AOU in 1944 at the early age of 36; Presidential Medal of Honor, presented by Jimmy Carter; Audubon Medal from the National Audubon Society; Gold Medal of the World Wildlife Fund, presented by Prince Bernhard of the Netherlands; Order of the Golden Ark from the Netherlands; Linnaeus Gold Medal from the Swedish Academy of Sciences, and the Smithson Medal from the Smithsonian Institution. He attended the dedication of the Charles Darwin Research Station in the Galapagos. RTP was happiest when serving as naturalist-lecturer aboard Lars-Eric Lindblad's *Explorer* on cruises to the Antarctic, Galapagos, Amazon River and Aldabra Atoll.

I detected two errors. Iceland is NOT north of the Arctic Circle (page 133). The Peregrine nest on the Sun Life building was in Montreal, not Toronto (page 229). I also regret that, in a book about people, the people index is incomplete, omitting some names entirely, and incompletely listing mentions of others.

Elizabeth J. Rosenthal, a graduate in both journalism and law, has previously written *His Song: the Musical Journey of Elton John*. Her Peterson life deals with a man of very different but not lesser talents, who was unusually helpful to beginner and expert alike, and whose personality shines through in the interview process. The potential audience includes the millions of people who began nature study with a Peterson field guide.

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NEW TITLES

Prepared by Roy John

†Available for review * Assigned

ZOOLOGY

Audubon: Early Drawings. By S. Edwards [Annotater]. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 272 pages. 125.00 USD Cloth.

* **Backyard Birdwatch.** By S. Kress. 2008. Dorling Kindersley/Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 72 pages. 11.95 CAD Paper.

* **Beautiful Minds: The Parallel Lives of Great Apes and Dolphins.** By M. Bearzi and C. Stanford. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 322 pages. 24.95 USD Cloth.

Butterfly. By T. Marent. 2008. Dorling Kindersley/Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 280 pages. 35.00 USD Paper.

Life in old Blood. By Sir D. Attenborough. 2008. Princeton University Press, 41 William Street, Princeton, New Jersey, 08540-5237 USA. 288 pages. 29.95 USD Cloth.

* **Ecology.** By M. Cain, W. Bowman and S. Hacker. 2008. Sinauer Associates Inc., Box 407, Sunderland, Massachusetts 01375-0407 USA. 621 pages. 107.95 USD.

Egg & Nest. By R. Purcell, L. Hall and R. Corado. 2008. Harvard University Press, 79 Garden Street Cambridge, Massachusetts 02138 USA. 224 pages. 39.95 USD Cloth.

Evolution. Edited by M. Ruse and J. Travis. 2009. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA.

* **The Ferocious Summer.** By M. Hooper. 2008. Greystone Books, #201-2323 Quebec Street, Vancouver, British Columbia V5T 4S7 Canada. 336 pages. 29.95 USD.

† **Fossil Ecosystems of North America.** By J. Nudds and P. Selden. 2008. University of Chicago Press, 5801 Ellis Avenue, Chicago, Illinois 60637 USA. 288 pages. 39.00 USD.

* **A Guide to the Mammals of China.** Edited by A. Smith and Y. Xie. 2008. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 576 pages. 60.00 USD.

* **A Guide to the Mammals of Southeast Asia.** By C. Francis. 2008. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 392 pages. 55.00 USD.

Seashore Life in the North Atlantic. By J. D. Duane. 2008. Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237 USA. 240 pages. 19.95 USD.

BOTANY

* **The Macrolichens of New England.** By James W. Hinds and Patricia L. Hinds. 2008. The New York Botanical Garden Press, 200th Street & Kazimiroff Boulevard, Bronx, New York 10458 USA. 600 pages. 65 USD Cloth.

MISCELLANEOUS

Culturing Wilderness in Jasper National Park. By I.S. MacLaren. 2008. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Canada. 312 pages. 39.95 CAD Paper.

Nahanni Journals – R.M. Patterson's 1927-1929 Journals. *Edited by* R. Davis. 2008. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Canada. 316 pages. 29.95 CAD Paper.

Ocean. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 512 pages. 27.95 USD Paper.

***Birdwatcher: The Life of Roger Tory Peterson.** By Elizabeth J. Rosenthal. 2008. The Lyons Press/Globe Pequot Press, Guilford, Connecticutt USA. 437 pages.

Smithsonian Rock and Gem. 2008. By Dorling Kindersley, Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 360 pages. 22.95 USD Paper.

Shelter at the Shore – The Boathouses of Muskoka. By J. De Visser and J. Ross. 2008. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 72 pages. 11.95 USD Paper.

YOUNG NATURALISTS

Dangerous Dinosaurs Q & A. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 64 pages. 14.99 USD Paper.

Encyclopedia of Dinosaurs & Prehistoric Life. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 376 pages. 22.99 USD Paper.

My Terrific Dinosaur Book. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 14 pages. 14.99 USD Cloth.

Earth Matters. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 256 pages. 27.99 USD Cloth.

Eyewitness Climate Change. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 72 pages. 18.99 USD Cloth.

Sharpedia. 2008. By Dorling Kindersley. Tourmaline Editions Inc., 662 King Street West, Suite 504, Toronto, Ontario M5V 1M7 Canada. 128 pages. 14.99 USD Cloth.

News and Comment

Bill Cody Receives Honorary Doctorate of Science from McMaster University, June 5, 2007

William James (Bill) Cody was born in Hamilton, Ontario in 1922. He grew up in Hamilton during the Depression. During summers, he worked on his uncle Bruce's fruit farm near St. David's in the Niagara Peninsula. He always enjoyed the outdoors, but it was with the help of McMaster University's Professor Lulu Gaiser that his love for plants grew. Bill received his bachelor's degree from McMaster University in 1946.

That same year, Bill joined the Canada Department of Agriculture at the Central Experimental Farm, in Ottawa, as Junior Agricultural Assistant. He was subsequently promoted to Senior Agricultural Assistant, Technical Officer and then Research Assistant. His enthusiasm for the outdoors led him to travel extensively during the summer months across nine provinces and two territories. During these excursions, he collected over 35,000 plant specimens. He has published over 343 articles, including books, scientific papers, and popular articles. He is Canada's leading expert on the flora of the Yukon and is an Honorary Research Associate with Agriculture and Agri-Food Canada.

Bill was appointed Curator of the Vascular Plant Herbarium in 1959. He held this position for 28 years. Under his supervision it became the largest vascular plant herbarium in Canada with more than one million specimens, including the thousands collected by him personally. The herbarium provides a basis for research and identification of economically important plants in Canada.

Officially retiring in 1987, after 41 years of service, Bill continues to go to the office. His expertise in identifying specimens and his knowledge is sought after by the younger generation of botanists. He remains an internationally recognized authority in Canada and continues to contribute to the development of the collection.

He joined the Ottawa Field-Naturalist's Club when he arrived in Ottawa in 1946. The position of Business Manager of a scientific journal, *The Canadian Field-Naturalist* was his for over 50 years. His duties included managing finances, monitoring stock, billing for reprints and public relations.

Bill was married for 47 years to Lois and together they raised five children: David, Margaret, Leslie, Douglas and Gordon. Having sung in a barber shop quartet and church choir, his joy of music was very evident. Bill's baritone voice could be heard resonating throughout the halls of his office and apartment building. He often had a pun or quip on the tip of his tongue.

In recent years, Bill had the opportunity to return to the Yukon four times. Each time, he took one of his children to help him collect and log specimens in order to determine range extensions and also to let them experience a place that had been a large part of his life.

Bill is very proud of his family heritage. His father, William MacPherson Cody, was the first appointed anesthetist to the Hamilton General Hospital. Also, his second cousin, 3 times removed, was William Frederick Cody, known to most as "Buffalo Bill" Cody, a famous hero of the American Wild West.

Among the tributes awarded to Bill are the following: the Lawson Medal, most prestigious award of the Canadian Botanical Association (1997); the Distinguished Technical Communication Award of the Society for Technical Communications (1997); induction into the McMaster University Alumni Gallery (2002); The Queen's Golden Jubilee Medal (2002); and the Yukon Biodiversity Awareness Award (2006).

Marine Turtle Newsletter (116)

April 2007. 36 pages: EDITORIALS: Proceeding to the future (M. S. Coyne) — The oldest place where there is always something new (J. G. Frazier) — ARTICLES: An update on marine turtles in Cote d'Ivoire, West Africa (J. G. Penate, M. Karamoko, S. Bamba, and G. Djadji) — An update on sea turtle conservation activities in the Republic of Congo (G. Bal, N. Brehert, and H. Vanleeuwe) — Conflicts and social dilemmas associated with the incidental capture of marine turtles by artisanal fishers in Benin (J. S. Dossa, B. A. Somsom and G. A. Mensah) — Marine turtle mortality in southern Gabon and northern Congo (R. Parnell, B. Verhage, S. L. Deem, H. Van Leeuwe, T. Nishihara, C. Moukoula, and A. Gibudi) — Artificial lights as a significant cause of morbidity of Leatherbacks in Pongara National Park, Gabon (S. L. Deem. F. Boussamba, A. Z. Nguema, G-P Sounguet, S. Bourgeois, J. Cianciolo, and A. Formia) — Observations of marine turtles in relation to seismic air-gun sond off Angola (C. R. Weir) — Fibropapillomatosis confirmed in *Chelonia mydas* in the Gulf of Guinea, West Africa (A. Formia, S. Deem, A. Billes, S. Ngouessono, R. Parnell, T. Collins, G-P Sounguet, A. Gibundi, A. Villarubia, G. H. Balazs, and T. R. Spraker) — Presence of sea turtles in traditional pharmacopoeia and beliefs of West Africa (J. Fretey, G. H. Segniagbeto, and M'M. Soumah) — Discovery of a Gabonese Leatherback in South Africa (J. Fretey, A. Billes, B. Baxter, and Caterine Hughes) — Second TAMAR-tagged Hawksbill recaptured in Corisco Bay, West Africa (A. Grossman, C. Bellini, A. Fallabrino, A. Formia, J. M. Mba, J. N. Mba, and C. Obama) — IUCN-MTSG QUARTERLY UPDATE — MEETING REPORTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS — ACKNOWLEDGEMENTS

The Marine Turtle Newsletter is edited by Lisa M. Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (Managing Editor), Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA; e-mail: mcoyne@seaturtle.org.

Atlas of amphibians and reptiles of Quebec, 2007 inventory

Instructions for participants in the 20th herpetological survey for the Québec Atlas of amphibians and reptiles, coordinated by the St. Lawrence Natural History Society in collaboration with the Ministère des Ressources naturelles de la Faune du Québec. The data from this annual inventory program are incorporated into the Centre de donnees sur le patrimone natural du Québec database; to date this database contains more than 60 000 date entries on Québec species. This provincial inventory is done every year with the important cooperation of volunteers. Contributors are encouraged to send their e-mail address and request for instruction on trasmitting data, Observation cards in paper format are available on request.

Mathieu Oulette, Research Officer, Research and Conservation, Ecomuseum – St. Lawrence Valley Natural History Society, 21 125 chemin Saint-Marie, Saint-Anne-de-Bellevue, Quebec H9X 3Y7; phone 514-457-9449; fax 514-457-0769; e-mail: info@herpetofaune.org.

The Boreal Dip Net/L'epousette boreale 11(1) Spring 2007

Newsletter of the Canadian Amphibian and Reptile Conservation Network/Réseau Canadien de Conservation des Amphibians et Reptiles

Contents: Editor's Note (Sara Ashpole) — Notes from the chairperson (David Galbraith) — Presentaions at CARCNET/RECCAR 2006 Annual Meeting, October, Victoria, British Columbia: Student Presentation Awards: Best Platform in 2006 Julie A. Lee-Yaw — Best Poster in 2006 Isabelle Deguise — 2006 Silver Salamander Award Mike Rankin (posthumously) — 2006 Silver Salamander Award: Fish & Wildlife Compensation Program: Jean Wai Jang — 2006 Silver Salamander Award: Gord McAdams and the West Kootenay Ecosociety: They stuck their necks out to save the turtles — 2006 Scholarship for Amphibian and Reptile Research: Gregory Bulte — Keynote Speakers with Extended Abstracts : Captive Breeding of Amphibians - Conservation or Cosmetic Surgery? (Richard A. Griffiths); The Way of a Gecko on a Rock — Why the Animal's Real Environment Matters — How the Student Presentations are Judged — Presentations Made (titles and authors of 50 presentations) — Book notice: Amphibians and Reptiles of British Columbia — Towards a Cooperative Strategy for Dealing with Disease Issues in Amphibian and Reptile Conservation — Blanding's Turtle Management Symposium and Roads and Ecopassages Forum — Announcement: CARRCNET/RECCAR Annual General Meeting 21 to 24 September 2007 Kingston, Ontario — CARCNET/RECCAR Board of Directors.

Canadian Association of Herpetologists/Association Canadienne des Herpetologists Bulletin 14(2) Spring 2007

Contents: Instructions for Authors — EDITORIAL NOTES: Membership and Association News — MEETINGS: CARCNet 11th Annual Meeting 27 to 29 October in Victoria, British Columbia; Joint Meeting of Ichthylogists and Herpetologists in St. Louis, Missouri, 11 to 16 July 2007 — FEATURE ARTICLE: Accuracy and precision of site occupancy estimates of anuran acoustic surveys when incorporating detection probabilities (Shane de Solla) — FIELD NOTES: Use of digital images obtained from volunteers to increase sample size and accuracy of morphometric ratios (Wayne Weller) — BOOK REVIEWS: *Herpetological Conservation and Biology* [an online journal] (assessed by Marc J. Mazerolle, Jim Bogart, Kate Jackson) — Diseases of Amphibians and Reptiles (reviewed by Dale A. Smith) — THESIS ABSTRACTS IN CANADIAN HERPETOLOGY: Sara M. Delannoy MSc 2006 University of Calgary, Alberta (Supervisor Anthony P. Russell) Subdigital setae of the Tokay Gecko: Variation in form and implication for adhesion; Patrick S. Druckenmiller PhD 2006 University of Calgary, Alberta (Supervisor Anthony P. Russell) Early Cretaceous Plesiosaurs (Sauroppterygia: Plesiosaura) from northern Alberta: Palaeoenvironmental and systematic implications; Virgil C. Hawkes MSc 2007 University of Victoria (Supervisor Patrick Gregory) Riparian management and ampibians: Does buffer width matter?; Geoffrey Hughes Honours BSc 2007 Laurentian University, Sudbury, Ontario (Supervisor Jacqueline Litzgus) Nest site selection by Wood Turtles (*Glyptemys insculpta*) in a thermally limited environment; Heather A. Jamniezky PhD 2006 University of Calgary, Alberta (Supervisor Anthony P. Russell) Turtle cranial arterial circulation: Intergrative analysis of a systematically influential character complex; Sheila Smith BSc 2006 Laurentian University, Sudbury, Ontario (Supervisor Jacqueline Litzgus) Geographic variation of sexual size dimorphism in Painted Turtles, *Chrysemys picta*; Eric D. Snively PhD 2006 University of Calgary, Alberta (Supervisor Anthony P. Russell) Neck musculoskeletal function in the Tyrannosauridae (Theropoda, Coelurosauria): Implications for feeding dynamics — THESES IN HERPETOLOGY AT THE UNIVERSITY OF VICTORIA (Patrick Gregory) a list by student and title for 33 theses (1974-2005): 9 BSc, 18 MSc, 6 PhD — RECENT PUBLICATIONS IN CANADIAN HERPETOLOGY: 17: 2006 (15), 2007(1), in press (1) — ANNOUNCEMENTS New Fiction Book about Sea Turtles: Sand Turtles.

Editor's Report for Volume 120 (2006)

Mailing dates for issues in volume 120(1) 15 July 2007, (2) 1 November 2007; (3) 30 November 2007; (4) 31 December 2007.

A summary of circulation to members and subscribers (institutional and individual) totals for 2006 is given in Table 1. The number of articles and notes in volume 121 is summarized in Table 2 by topic; totals for Book Reviews and New Titles are given in Table 3, and the distribution of content by page totals per issue in Table 4.

Council continued to authorize 40% of membership dues for publication of the journal and all of subscriptions (both individual and institutional). Council also has allocated 80% of the annual interest from the Manning Fund and other capital funds to *The Canadian Field-Naturalist*. Use of the Manning fund portion was broadened on an issue-by-issue basis to offset the publication costs where authors lacked grant or institutional funds to support publication.

The journal was printed at Gilmore Printers, Ottawa, and thanks are due business representative Tom Smith; customer representative Chuck Graham for overseeing production, and Wendy Cotie for typesetting and corrections. Leslie Cody prepared the Index for volume 120; Elizabeth Morton proofed the galleys. When Bill Cody, Businesss Manager for 60 years, was unable to carry on, most of his duties were shouldered by Treasurer Frank Pope and Assistant Treasurer Jim Ward with invoice preparation assumed by the editor. Roy John arranged and edited book reviews and prepared the New Titles listings. Special thanks are due to Jenifer Penny, Program Botanist, B.C. Conservation Data Centre, Victoria, British Columbia, for editing and revising for 120(1) the eight papers on conservation evaluation of some British Columbia plants originated by the late George Douglas and also for preparing the tribute and updated bibliography for Douglas. The journal contents and abstracts are now posted on the Ottawa Field-Naturalists' Club website by webmaster Sandra Garland, and PDFs may be ordered by authors as well as traditional print reprints.

TABLE 2. Number of articles and notes published in *The Canadian Field-Naturalist* Volume 120 (2006) by major field of study.

Subject	Articles	Notes	Total
Mammals	22	6	28
Birds	8	5	13
Amphibians + reptiles	1	1	2
Fish	5	3	8
Insects	3	0	3
Other invertebrates	1	1	2
Plants	13	0	13
Paleontology	1	0	1
Tributes	2	0	2
Totals	56	16	72

Manuscripts (excluding book reviews, notices, and reports) submitted to *The Canadian Field-Naturalist* totalled 67 in 2006, down by 8 from the total for 2005. The following reviewed for papers submitted in 2006 (with number of manuscripts reviewed in parentheses if more than one):

Associate Editors: R. Anderson, Canadian Museum of Nature, Ottawa, Ontario; C. D. Bird, Erskine, Alberta (8); R. R. Campbell, St. Albert, Ontario (2); P. M. Catling, Agriculture and Agri-food Canada, Ottawa, Ontario (5); B. W. Coad, Canadian Museum of Nature, Ottawa, Ontario (6); A. J. Erskine, Sackville, New Brunswick (10); D. F. McAlpine, New Brunswick Museum, Saint John, New Brunswick (4); D. W. Nagorsen, Mammalia Biological Consulting, Victoria, British Columbia (8); W. O. Pruitt, Jr., University of Manitoba, Winnipeg, Manitoba (6).

TABLE 1. The 2006 circulation of *The Canadian Field-Naturalist* (2005 in parentheses). Prepared by Robin Murphy, bmr group, Ottawa. Totals are copies mailed. As some members opt not to receive the journal, membership total here is only those receiving the journal. For total club membership see the Annual Report of the membership committee to the 2007 Annual Business Meeting.

	Canada		USA		Other		Totals	
Memberships								
Family & individual	556	(624)	24	(26)	5	(6)	585	(656)
Subscriptions								
Individuals	131	(130)	57	(63)	5	(4)	193	(197)
Institutions	158	(156)	232	(229)	32	(34)	422	(419)
TOTALS	845	(910)	313	(318)	42	(44)	1200	(1272)

Note: 20 countries (outside Canada and United States) are included under "Other" (number of copies in parentheses): Australia, Austria, Belgium, Brazil, Denmark, United Kingdom (9: including 1 to Scotland), Finland (2), France (2), Germany (2), Iceland, Ireland, Japan, Netherlands (2), New Zealand, Norway (6), Poland, Russia, South Africa, Spain (2), Switzerland, Taiwan (2).

TABLE 3. Number of reviews and new titles published in Book Review section of *The Canadian Field-Naturalist* Volume 120 (2006) by topic.

	Reviews	New Titles
Zoology	37	126
Botany	4	15
Environment	9	58
Miscellaneous	10	4
Young Naturalists	1	5
Totals	61	208

TABLE 4. Number of pages per section published in *The Canadian Field-Naturalist* Volume 120 (2006) by issue.

	(1)	(2)	(3)	(4)	Total
Articles	105	85	104	68	362
Notes	7	11	3	12	33
Tributes	0	12	9	0	21
Book Reviews*	19	15	13	19	66
CFN/OFNC Reports**	0	2	9	5	16
News and Comment	2	2	1	2	7
Index	0	0	0	21	21
Advice to Contributors	1	1	1	1	4
Totals	134	128	140	128	530

* Total pages for book review section include both reviews and new titles listings.

** Includes CFN Editor's report in (2), OFNC Annual Business Meeting (3) and OFNC Awards (4).

Other Reviewers: P. Achuff, Waterton Lakes, Alberta; W. B. Ballard, Texas Tech University, Lubbock, Texas (4); J. R. Bider, Baie d'Urfe, Quebec (2); G. Blouin-Demers, University of Ottawa, Ontario; E. L. Bousfield, Victoria, British Columbia (2); K. Conlan, Canadian Museum of Nature, Ottawa (2); D. Boyd, Helena, Montana; R. J. Brooks, University of Guelph, Ontario; S. Carriere, Environment and Natural Resources, Yellowknife, Northwest Territories; R. W. Campbell, Biodiversity Centre for Wildlife Studies, Victoria, British Columbia; J. A. Cook, Museum of Southwestern Biology, University of New Mexico, Albuquerque; S. Cooke, Carleton University, Ottawa, Ontario (2); W. J. Crins, Ontario Ministry of Natural Resources, Peterborough, Ontario; D. B. Donald, Environment Canada, Regina, Saskatchewan; J. Dubois, Manitoba Natural Resources, Winnipeg, Manitoba; J. Ferron, Universite du Quebec a Rimouski, Quebec; D. R. Galbraith, Royal Botanical Gardens, Hamilton, Ontario; A. J. Gaston, Environment Canada, Gatineau, Quebec; D. Giblin, Burke Museum, University of Washington, Seattle, Washington; J. Gilhen, Nova Scotia Museum of Natural History, Halifax, Nova Scotia (2); P. Goossen, Environment Canada, Edmonton, Alberta; P. T. Gregory, University of Victoria, British Columbia; F. H. Harrington, Mt. St. Vincent University, Halifax, Nova Scotia; S. J. Hecnar, Lakehead University, Thunder Bay, Ontario; E. Hendrycks, Canadian Museum of Nature, Ottawa, Ontario; P. Hicklin, Environment Canada, Sackville, New Brunswick; L. V. Hills, Cochrane, Alberta; S. Hooker, University of St. Andrews, Fife, United Kingdom; B. D. Johnson, Herbarium, Northern Forest Research Centre, Canadian Forest Service, Edmonton, Alberta (2); C. S. Houston, Saskatoon, Saskatchewan; J. Kamler, Polish Academy of Sciences, Bialowieza, Poland; C. R. Lacroix, University of Prince Edward Island, Charlottetown; J. Lanteigne, Travaux publics et services, gouvernementaux Canada, Gatineau, Quebec; G. Lee, Ottawa, Ontario; R. MacCulloch, Royal Ontario Museum, Toronto, Ontario; J. Madill, Canadian Museum of Nature, Ottawa, Ontario; F. F. Mallory, Laurentian University, Sudbury, Ontario (2); M. Mallory, Environment Canada, Iqaluit, Nunavut; André Martel, Canadian Museum of Nature, Ottawa, Ontario; L. D. Mech, U.S. Geological Survey, The Raptor Center, University of Minnesota, St. Paul (3); J. Metcalfe-Smith, Aquatic Ecosystem Protection Branch, National Water Research Institute, Burlington, Ontario; A. Moehrenschlager, Calgary Zoological Society, Alberta; E. L. Mills, Dalhousie University, Halifax, Nova Scotia; G. Morrison, Environment Canada, Gatineau. Quebec; G. Parker, Environment Canada, Sackville, New Brunswick; E. Pip, University of Winnipeg, Manitoba; G. Pohle, Huntsman Marine Science Centre, St. Andrews, New Brunswick; W. Preston, Winnipeg, Manitoba; G. Proulx, Alpha Research & Management Ltd., Sherwood Park, Alberta (2); R. Reeves, Okapi Wildlife Associates, Hudson, Quebec (2); T. E. Reimchen, University of British Columbia, Victoria, British Columbia; G. J. Robertson, Environment Canada, Mount Pearl, Newfoundland; L. Rogers, Ely, Minnesota; R. Rosatte, Ministry of Natural Resources, Trent University, Peterborough, Ontario; A. Russell, University of Calgary, Calgary, Alberta; F. Scott, Acadia University, Wolfville, Nova Scotia; F. W. Schueler, Bishops Mills Natural History Center, Oxford Mills, Ontario; J. W. Sheard, University of Saskatchewan, Saskatoon; Brian Slough, Whitehorse, Yukon Territory; K. W. Stewart, University of Manitoba, Winnipeg, Manitoba (3); P. Weatherhead, Queen's Biological Station, Elgin, Ontario; M. J. Wetzell, Illinois, Natural History Survey, Champaign, Illinois; N. Yan, York University, North York, Ontario.

I am also indebted once again to the President of the Ottawa Field-Naturalists' Club, Gary McNulty, and the Club Council for continuing support of the journal; Chairman Ron Bedford and the Publications Committee of the OFNC for editorial encouragement and support, the Finance Committee for input and encouragement to speed things up, the Canadian Museum of Nature for access to its library and the facilities at the Natural Heritage Building, 1740 Pink Road, Aylmer, Quebec, and to Joyce for everything else.

I must add my special thanks due William J. (Bill) Cody who served the club as council member for more than 60 years, vitually all ot this time as Business Manager of *The Canadian Field-Naturalist*. Those of us exposed to Bill's unfailing good humour, determination, efficient focus on the job on hand, and sometimes his inevitable serenades, have lasting memories of the time shared. Bill served with, and kept each on track, five editors (one twice) — Harold Senn to 1955), Bob Hamilton (1956-1961), myself (1962-1966), Ted Mosquin (1967-1972), Lorraine Smith (1972-1981, and me again (1981 — present). Efficient management and financial stability through good times and bad were due in large measure to Bill's initiative which assured, in some periods, the journals very survival.

A decade ago, to mark 50 years of service, the club paid tribute to Bill's contribution to that point with a reception at the Central Experimental Farm, Department of Agriculture, Ottawa, where Bill had spent his whole career, including "retirement", as a research botanist. Stephen Darbyshire for Awards Committee stated in part (1998. Canadian Field-Naturalist 112(4): 719-720):

> "Such long-term service and dedication is unprecedented in the history of the Club and is not likely to ever be repeated. The titles of office do not reveal the extent to which Bill has laboured for the Club. One cannot completely list the jobs that he has taken on (even Bill cannot remember them all), many of which are among the most distasteful and time consuming (imagine the years of dealing with government forms for postage rates, charitable status, etc.). Executive officers have come and gone, Canadian Field-Naturalist editors have come and gone, Council is re-elected every year, but Bill Cody continues as a major constituent of the glue that keeps the Club together and keeps it, and its scientific publication, running smoothly."

Bill continued to perform these duties for close to another decade before failing health forced him pass them on to others. The full truth in the earlier words of tribute has become increasingly realized by those of us Bill left to share his multitude of tasks. Most of the burden has fallen on Frank Pope, already contributing tremendous service as Treasurer of the Ottawa Field-Naturalist's Club, and Jim Ward as Treasurer's Assistant. They have made the transition work.

FRANCIS R. COOK
Editor

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit by post **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** Manuscripts may also be submitted (one copy) by e-mail. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be printed on standard-size paper, **doublespaced throughout,** generous margins to allow for copy marking, and **each page numbered.** For Articles and Notes provide a bibliographic (citation) strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Photographic reproduction of line drawings should be **no larger than a standard page.** Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the joumal.

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Limited joumal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

Reprints

An order form for the purchase of reprints or pdf will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor
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The Ottawa Field-Naturalists' Club

FOUNDED IN 1879

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Her Excellency The Right Honourable Michaïlle Jean
Governor General of Canada

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

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The Canadian Field-Naturalist

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Book-review correspondence should be sent by e-mail or postal mail to Roy John, Book-review Editor.

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COVER: A Red-winged Blackbird nest with three blackbird eggs and five Brown-headed Cowbird eggs. The nest was found in Conservation Reserve Program grassland in Day County, South Dakota. Photographed on 16 June 2005 by Lawrence I Igl. See article on cowbird parasitism by Igl and Johnson, pages 239-255.

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The Canadian Field-Naturalist

Volume 121, Number 3 April–June 2007

Brown-headed Cowbird, *Molothrus ater*, Parasitism and Abundance in the Northern Great Plains

Lawrence D. Igl[1] and Douglas H. Johnson[2]

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The Brown-headed Cowbird (*Molothrus ater*) reaches its highest abundance in the northern Great Plains, but much of our understanding of cowbird ecology and host-parasite interactions comes from areas outside of this region. We examine cowbird brood parasitism and densities during two studies of breeding birds in the northern Great Plains during 1990–2006. We found 2649 active nests of 75 species, including 746 nonpasserine nests and 1902 passerine nests. Overall, <1% of nonpasserine nests and 25% of passerine nests were parasitized by Brown-headed Cowbirds. Although the overall frequency of cowbird parasitism in passerine nests in these two studies is considered moderate, the frequency of multiple parasitism among parasitized nests was heavy (nearly 50%). The mean number of cowbird eggs per parasitized passerine nest was 1.9 ± 1.2 (SD; range = 1–8 cowbird eggs). The parasitism rates were 9.5% for passerines that typically nest in habitats characterized by woody vegetation, 16.4% for grassland-nesting passerines, 4.7% for passerines known to consistently eject cowbird eggs, and 28.2% for passerines that usually accept cowbird eggs. The Red-winged Blackbird (*Agelaius phoeniceus*) was the most commonly parasitized species (43.1% parasitism, 49.6% multiple parasitism, 71.2% of all cases of parasitism). Passerine nests found within areas of higher female cowbird abundance experienced higher frequencies of cowbird parasitism than those found in areas of lower female cowbird abundance. Densities of female cowbirds were positively related to densities and richness of other birds in the breeding bird community.

Key Words: Brown-headed Cowbird, *Molothrus ater*, brood parasitism, grasslands, multiple parasitism, spatial variation, temporal variation, northern Great Plains.

The Brown-headed Cowbird (*Molothrus ater*; hereafter cowbird) is an obligate brood parasite that lays its eggs in nests of a variety of host species. Cowbird distribution, abundance, and brood parasitism have long been major topics in avian ecology in North America (Nice 1937; McGeen 1972; May and Robinson 1985; Ortega 1998; Herkert et al. 2003). Cowbird abundance and rates of brood parasitism vary geographically (Robinson et al. 1995; Ortega 1998; Rothstein and Robinson 1998). The cowbird reaches its highest abundance in the northern Great Plains (Sauer et al. 2005*), yet much of our understanding of cowbird parasitism and the dynamics of host and parasite populations comes from areas outside of this region. Nonetheless, some studies have reported high rates of cowbird parasitism and multiple parasitism in the northern Great Plains (e.g., Linz and Bolin 1982; Romig and Crawford 1995; Davis and Sealy 2000; Koford et al. 2000). Robinson and Smith (2000), however, suggested that some of these oft-cited studies may not be representative of the northern Great Plains. There are few published examples of community-wide studies of cowbird parasitism in the northern Great Plains (e.g., Granfors et al. 2001; Woolfenden et al. 2004). Rather, most reports of cowbird parasitism from this region focus on a single species (e.g., Linz and Bolin 1982), a subset of species (e.g., Winter et al. 2004), or species that have evolved defenses against cowbird parasitism (Sealy 1996).

At the continental level, cowbird abundance declines with distance from the center of the species' breeding range in the northern Great Plains (Thompson et al. 2000). The frequencies of cowbird parasitism appear to follow a similar biogeographical pattern (e.g., Smith and Myers-Smith 1998), especially for grassland birds (Jensen and Cully 2005a, 2005b), although this relationship may not be generalized across habitats (Robinson and Smith 2000) and may not be indicative of parasitism frequencies at the local level (Chace et al. 2005). Nonetheless, Chace et al. (2005) acknowl-

edged that, at the continental scale, cowbird abundance appears to be a reasonable predictor of cowbird parasitism levels. Because of the difficulty in obtaining data on both cowbird abundance and brood parasitism across the continent (or even over a large region), there are few examples of studies that have evaluated this relationship using cowbird and nest data collected concurrently at the same study sites over a large region (e.g., Robinson et al. 2000; Jensen and Cully 2005a, 2005b). Only a few evaluations of this biogeographical relationship have included data from study sites in the northern Great Plains (e.g., Smith and Myers-Smith 1998; Herkert et al. 2003).

At local and regional scales, geographic differences in cowbird distribution and abundance also may result from differences in avian communities (e.g., Farmer 1999; Thompson et al. 2000). That is, given that cowbirds are host generalists, measures of avian abundance or richness might serve as proximate cues for cowbirds in determining where to settle (McGeen 1972; Farmer 1999). Chace et al. (2005) listed four nested levels of an avian community that cowbirds could use as cues for settlement: (1) all breeding birds in the avian community, (2) all passerine species, (3) all host species, and (4) a single host species. Very few studies have evaluated this relationship at all four levels (Farmer 1999). Using BBS (Breeding Bird Survey) data, Hahn and O'Connor (2002) concluded that cowbird distribution was not simply the result of shared habitat preferences with their hosts, but rather host abundance was an important predictor of cowbird occurrence in recently colonized regions of the United States (i.e., eastern and western states) and to a lesser extent in the cowbird's ancestral range (i.e., central Great Plains). Except for Hahn and O'Connor's (2002) evaluation using BBS data, the influences of avian abundance and richness on cowbird distribution and abundance have not been evaluated using regional data from the northern Great Plains (reviewed in Chace et al. 2005).

In this paper, we report cowbird densities and parasitism frequencies during two breeding-bird studies in the northern Great Plains: a statewide study in North Dakota (1992 and 1993: Igl and Johnson 1997; Igl et al. 1999) and a Conservation Reserve Program (CRP) grassland study in nine counties of four states (1990–2006: Johnson and Schwartz 1993a, 1993b; Igl and Johnson 1995, 1999; Johnson and Igl 1995, 2001). We use data from nests found incidentally during both studies to examine weekly and annual variation in parasitism rates in the northern Great Plains, and nest data from the CRP grassland study to examine regional variation in parasitism rates. We use data from the long-term CRP grassland study to evaluate the relationships between female cowbird densities and cowbird parasitism and between female cowbird densities and avian densities and richness in different regions of the northern Great Plains. CRP grasslands are a suitable habitat to evaluate these relationships because this habitat has been shown to be a dominant landscape predictor of cowbird distribution in the United States (Hahn and O'Connor 2002).

Study Areas

North Dakota statewide study

The study area for the North Dakota statewide study was described in detail by Stewart and Kantrud (1972) and Igl and Johnson (1997) and is only briefly described here. North Dakota was divided into eight major strata based on biogeographical, physiographical, and ecological characteristics. From these eight strata, 130 quarter-sections (about 64.75 ha each) were selected randomly (Figure 1). The number of sample units allocated to each stratum was proportional to the area of the stratum. Landowners denied access to one quarter-section in 1992 and a different quarter-section in 1993.

CRP grassland study

The CRP study is an ongoing investigation (1990 to present) that is examining breeding-bird communities annually in nearly 350 CRP grassland fields in nine counties of four states (Figure 2), including Fallon and Sheridan counties in Montana; Hettinger, Kidder, and Eddy counties in North Dakota; Butte, McPherson, and Day counties in South Dakota; and Grant County in Minnesota (Johnson and Schwartz 1993a, 1993b). Field size varied from <1.0 to 111.7 ha. In the northern Great Plains, most CRP land was planted to a mixture of native and/or non-native grasses and legumes (Johnson and Schwartz 1993a). Woody vegetation has encroached into some idle CRP fields, and some CRP fields contain wetlands or were partially inundated by water during a recent wet period (Igl 2001; Igl and Johnson, unpublished data).

Methods

Breeding bird and cowbird surveys

In both studies, we conducted total area counts of breeding birds using the strip-transect procedure employed by Stewart and Kantrud (1972; also see Igl and Johnson 1997). During the North Dakota statewide study, bird surveys were conducted by two observers on foot, and each observer surveyed cowbirds and other breeding birds on a rectangular half (805 * 402 m; 32.37 ha) of a quarter-section by following a standardized survey route. This route was 100 m inside of, and parallel to, the boundary of the rectangle. The rectangular halves were usually surveyed simultaneously, and an interval of 400 m was maintained between observers. Deviations of up to 100 m from the route were often necessary to adequately survey all habitats.

Bird species were identified by sight or sound. Counts during precipitation and strong winds (> 24 km/h) were avoided. Surveys of open country birds were conducted between 0.5 h after sunrise and 15:00 CST. Although some surveys occurred outside the time of

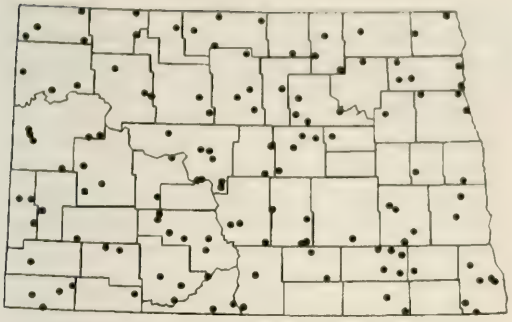

FIGURE 1. Distribution of 130 quarter-sections (64.75 ha each) in North Dakota in which bird surveys were conducted during the breeding seasons in 1992 and 1993.

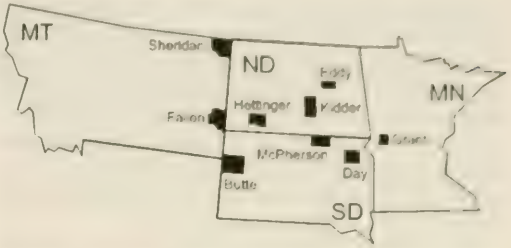

FIGURE 2. Counties in which Conservation Reserve Program grassland fields were surveyed for breeding birds in North Dakota, South Dakota, Minnesota, and Montana, 1990–2006.

most active bird vocalizations (i.e., early morning or late evening), Stewart and Kantrud (1972) concluded that singing and other activities of open-country birds were not appreciably affected by time of day (also see Vickery 1995*). Quarter-sections containing extensive woodland habitats were usually covered on relatively calm (<8 km/h), sunny days between 0.5 h after sunrise and 10:00 CST. These limitations were necessary because song frequencies and other activities of most woodland birds are reduced on cloudy days, in moderate or high winds, and at mid-day.

Counts of breeding birds were based primarily on the number of indicated breeding pairs on territories or home ranges during peak breeding periods. All sample units were surveyed for early-nesting species between 24 April and 7 June, for mid-nesting species between 14 May and 10 July, and for late-nesting species between 22 May and 21 July. When a survey was conducted during an overlapping portion of the peak breeding periods, counts of early-, mid-, and late-nesting species coincided. Thus, quarter-sections that were visited between 22 May and 7 June were only surveyed once, and those that were surveyed before 22 May were surveyed again after 7 June so as to include species from all three breeding periods. For most species, nearly all indicated pairs were observed as segregated pairs or as territorial males. For the sexually dimorphic Brown-headed Cowbird, we separately tallied the males and females seen per sample unit; herein, we report only female cowbird densities. We did not consider certain birds observed during the censuses to be breeding and excluded them from our results. These included late-migrating flocks and other birds passing overhead in high, direct flight. By counting birds only during their peak breeding periods, we maximized the potential for recording breeding birds and, at the same time, minimized the likelihood of confounding breeding birds with migrants.

In the CRP study, total area counts of breeding birds were conducted by using a minor modification of the strip-transect procedures used by Stewart and Kantrud (1972) and Igl and Johnson (1997). Small fields usually were surveyed by a single observer; large fields typically were surveyed by two observers on foot, each simultaneously covering about one-half of the field. The number and configuration of transects were consistent among years but varied depending upon the field size and shape to achieve total coverage of a field. We surveyed each CRP grassland field once each year between 21 May and 9 July in 1990–2006.

Nests and cowbird parasitism

Prior to entering the field in each year, the observers were trained in bird, nest, and egg identification. Nests were found serendipitously during breeding bird surveys and related research activities. Most nests were found by unintentionally flushing an adult host (or rarely a female cowbird) from the nest or nest vicinity. The remainder of the nests were found by observers as they were simply walking through a habitat. When a nest was located, we inspected it and recorded the species (based on the identification of the flushing adult, the nest, or the nest contents) and the number of eggs or nestlings of the host and of cowbirds. If the nest species could not be identified at the time of the initial observation, the nest location was temporarily marked and then revisited and identified at the end of the survey by an experienced observer. We classified a nest as parasitized if it contained at least one cowbird egg or nestling, regardless of the stage of the nesting cycle. Cowbird and host nestlings were identified based on size, gape and flange colors, and down or contour feather characteristics and development. We were unable to return to nests to monitor their outcome or to document additional brood parasitism. We rarely located or checked the contents of nests of upper-canopy nesting species. Most of the nests that we located were found in the egg-laying stage or the incubation stage (see below); cowbirds lay most of their eggs before or during the hosts' egg-laying stage (Johnsgard 1997). Although we found many nests in the nest-building stage (i.e., before the onset of egg laying), we summarize here only active nests, which we defined as nests attended by adults that contained at least one host or cowbird egg and/or nestling. We also

found a few abandoned nests that contained cowbird eggs, but these are not reported because cowbirds are known to parasitize inactive nests (Freeman et al. 1990). The presence of cowbird fledglings that were fed by adult hosts also was noted during the surveys of breeding birds, although an observation of a potential host feeding a cowbird fledgling does not establish conclusively the true foster-parentage of the fledgling cowbird (sensu Klein and Rosenberg 1986).

We use the frequency (%) of nests parasitized as an index to the levels of parasitism. We define the frequency (%) of cowbird parasitism as the total number of parasitized nests (*100) divided by the total number of active nests found for a given species, group of species (e.g., grassland birds), county, or time period (week or year). We define the frequency (%) of multiple parasitism as the total number of nests containing more than one cowbird egg (*100) divided by the total number of parasitized nests found for a given species, group of species, county, or time period. The average (± SD) number of cowbird eggs per parasitized nest (i.e., parasitism intensity) was calculated by summing the number of cowbird eggs found in all parasitized nests in both studies and dividing by the total number of parasitized nests. Although cowbirds may avoid parasitizing nests of ejector species (Sealy and Bazin 1995), we include nests of all passerine species, because ejector species are sometimes parasitized (e.g., Scott 1977; Peer et al. 2000), because parasitism of ejector species may vary geographically (e.g., Haas and Haas 1998) or with time of sympatry with cowbirds (Briskie et al. 1992), and because it is difficult to estimate how often ejector species are parasitized (e.g., Scott 1977). To evaluate changes in cowbird parasitism within the breeding season, we divided each month into four, roughly weekly, periods (7, 8, 7[8] and 8 days, respectively) (sensu Orians et al. 1989). For discussion purposes, we grouped rates of parasitism and multiple parasitism into five categories: low (<10%), low-to-moderate (10–20%), moderate (20–40%), moderate-to-heavy (40–50%), and heavy (>50%) (sensu Ortega 1998: 184). Scientific names of potential host species are included in Table 2.

To determine whether cowbirds avoid laying eggs in previously parasitized nests (Mayfield 1965a; Orians et al. 1989), we evaluated the distribution pattern of cowbird eggs (i.e., random or non-random) using a zero-truncated Poisson distribution model for only parasitized nests (Lindsey 1997). A random distribution of cowbirds eggs suggests that female cowbirds did not discriminate among parasitized nests and that the proportion of nests with 1, 2, 3, 4, …, i cowbird eggs approximated a Poisson distribution (Orians et al. 1989). A non-random distribution of cowbird eggs indicated that the random distribution model was rejected ($P < 0.01$).

For both studies, we calculated overall parasitism frequencies, mean densities of female cowbirds, mean avian densities, and mean avian richness. For the CRP grassland study, we calculated mean avian density and richness among five groups (all of which excluded cowbirds): (1) all avian species, (2) all passerine species, (3) all passerines known to have raised cowbird young (Ortega 1998; Davis and Sealy 2000), (4) all passerines excluding ejectors (Peer and Sealy 2004), and (5) a single, preferred host (i.e., Red-winged Blackbird; see below). We were interested in the regional avian influences that affect cowbird distribution and abundance rather than short-term influences, and thus we averaged across the 17 years within a county and did not analyze the survey data separately for individual years. For the CRP grassland study, we used female cowbird densities both as an explanatory variable in relation to rates of cowbird parasitism and as a response variable in relation to avian community variables (i.e., density and richness). Linear regression analyses (PROC REG; SAS Institute, Inc. 2004) were performed (1) to determine the relationship between overall cowbird parasitism and female cowbird densities, and (2) to examine the relationship between female cowbird densities and the five levels of the avian community.

Results

In the North Dakota study, we observed 160 breeding bird species, including 78 nonpasserine species and 82 passerine species (Igl and Johnson 1997). Given that grasslands, croplands, and wetlands are the three most common habitats in North Dakota (Igl and Johnson 1997), most of the common breeding bird species in North Dakota are associated with such open habitats. The five most abundant species in the North Dakota study, in decreasing order of abundance, were the Horned Lark, Chestnut-collared Longspur, Red-winged Blackbird, Western Meadowlark, and Lark Bunting (scientific names given in Table 2). Average breeding bird densities in a quarter-section, excluding cowbirds, were 126 breeding pairs per 100 ha in 1992 and 143.9 breeding pairs per 100 ha in 1993 (Table 1). The average numbers of species observed in a quarter-section (64.75 ha) were 18.5 species in 1992 and 21.6 species in 1993. Average cowbird densities were 3.0 female cowbirds per 100 ha in 1992 and 4.3 female cowbirds per 100 ha in 1993. Female Brown-headed Cowbirds were found in 66.7 and 76.7% of the quarter-sections in 1992 and 1993, respectively.

In the CRP grassland study, we observed 143 breeding bird species, including 78 nonpasserine species and 65 passerine species. The five most abundant species, in decreasing order of abundance, were Savannah Sparrow, Grasshopper Sparrow, Red-winged Blackbird, Clay-colored Sparrow, and Western Meadowlark. Average breeding-bird densities within a county (averaged across years and excluding cowbirds) ranged from 104.1 to 208.1 breeding pairs per 100 ha, and the average number of species observed within a county ranged from 26.8 to 52.7 species (Table 1). Average cowbird densities within a county ranged from 0.6 to 8.0 female cowbirds per 100 ha, and the average annual

TABLE 1. Summary of Brown-headed Cowbird densities (females/100 ha), cowbird occurrence, breeding bird density (all species excluding cowbirds; breeding pairs/100 ha), and number of breeding bird species per quarter section in two studies in the northern Great Plains, 1990-2006.

Year or Study Location	Female cowbird density		Female cowbird occurrence		Breeding bird density		Number of breeding bird species	
	Mean	SE	Mean %	SE	Mean	SE	Mean	SE
North Dakota statewide study								
1992	3.0	0.3	0.67	–	126.0	7.8	18.5	0.8
1993	4.3	0.5	0.77	–	143.9	7.3	21.6	0.9
CRP grassland study (1990–2006)								
Butte County, South Dakota	0.6	0.1	0.14	0.02	105.8	5.9	28.5	1.4
Day County, South Dakota	8.0	0.7	0.54	0.03	208.1	14.5	48.8	2.7
Eddy County, North Dakota	6.3	0.4	0.49	0.03	188.7	15.1	45.5	2.5
Fallon County, Montana	0.9	0.2	0.12	0.02	104.1	9.1	26.8	1.2
Grant County, Minnesota	3.1	0.4	0.25	0.02	181.8	13.7	39.6	2.2
Hettinger County, North Dakota	5.7	0.5	0.52	0.03	160.0	9.3	33.2	1.3
Kidder County, North Dakota	5.9	0.3	0.50	0.01	160.2	14.1	52.7	2.8
McPherson County, South Dakota	7.1	0.5	0.54	0.02	164.5	9.8	43.8	2.4
Sheridan County, Montana	2.8	0.9	0.29	0.05	122.3	7.4	30.4	1.1

frequency of female cowbird occurrence ranged from 12.4 to 54.1%. Average cowbird densities and frequencies were lowest in the counties on the eastern and western edges of our study area (Table 1, Figure 2). This pattern mirrors cowbird distribution maps from the North American BBS (Price et al. 1995; Sauer et al. 2005*), which show cowbird abundance declining both east and west of central North Dakota and South Dakota.

We found 351 active nests of 51 species (18 nonpasserine and 33 passerine species) during the North Dakota statewide study and 2298 active nests of 62 species (23 nonpasserine and 39 passerine species) during the CRP grassland study, for a total of 2649 nests of 75 species (Table 2). Most of the nests of nonpasserine species were found during the egg-laying or incubation stages; 89.9% of the 746 nests of nonpasserine species contained only eggs, and 10.1% contained only nestlings or both eggs and nestlings. Only one nonpasserine nest was parasitized by a cowbird (Table 2). An Upland Sandpiper nest with four sandpiper eggs and one cowbird egg was found in a CRP grassland field in Sheridan County, Montana, on 28 June 1993. Hereafter, we summarize data only for passerine nests.

Most of the active nests of passerines were found during the egg-laying or incubation stages; 85.8% of the 1902 passerine nests contained only eggs, and 14.2% of the nests contained only nestlings or both eggs and nestlings. Overall, the parasitism rate of passerine nests was moderate; 476 of the 1902 (25%) passerine nests that we found during the two studies were parasitized by cowbirds (Table 2).

Twenty-four of the 45 passerine species were found parasitized (Table 2). Among species with 25 or more nests, parasitism levels were low for Western Kingbird (0%), Eastern Kingbird (1.7%), Brown Thrasher (3.8%), Savannah Sparrow (9.8%), Chestnut-collared Longspur (7.7%), and Common Grackle (1.1%); low-to-moderate for Horned Lark (15.6%), Clay-colored Sparrow (11.7%), Lark Bunting (19.4%), Grasshopper Sparrow (19.7%), Bobolink (19.2%), and Western Meadowlark (16.1%); moderate for Brewer's Blackbird (33.3%); and moderate-to-heavy for Red-winged Blackbird (43.1%). The Red-winged Blackbird was the most commonly parasitized species in the two studies (71.2% of all cases of parasitism), and we classified it as a preferred host in subsequent analyses.

Parasitized passerine nests contained from zero to six host eggs and/or nestlings and from one to eight cowbird eggs and/or nestlings (Table 3). Of the 476 parasitized passerine nests, 50.6% contained one cowbird egg, 28.6% contained two, 12.0% contained three, and 8.8% contained four or more cowbird eggs. The maximum number of eggs or nestlings in a parasitized nest (host and cowbird combined) was nine. The average number of cowbird eggs per parasitized nest was 1.9 ± 1.2 (Tables 2 and 3). Multiple parasitism occurred at 12.4% of all passerine nests and at 49.4% of all parasitized passerine nests. Parasitized nests of 18 passerine species contained multiple cowbird eggs and/or nestlings (Table 2). Among parasitized species with 25 or more nests, multiple parasitism rates were low for Eastern Kingbird (0%), Brown Thrasher (0%), and Common Grackle (0%); moderate-to-heavy for Clay-colored Sparrow (43.5%), Lark Bunting (38.9%), Grasshopper Sparrow (44.4%), Chestnut-collared Longspur (50.0%), and Red-winged Blackbird (49.6%); and heavy for Horned Lark (80.0%), Savannah Sparrow (62.5%), Bobolink (53.3%), Western Meadowlark (100%), and Brewer's Blackbird (58.3%). Among these species, the average number of cowbird eggs per parasitized nest was highest for the Western Meadowlark (3.4 ± 1.6); all nine parasitized nests of the Western Meadowlark contained two or more cowbird eggs.

TABLE 2. Brown-headed Cowbird parasitism in nests of birds found incidentally during two breeding-bird studies in the northern Great Plains, 1990–2006.

Species [a]	Breeding habitat association[b]	Incidence of cowbird parasitism: North Dakota statewide study[c]	Incidence of cowbird parasitism: Conservation Reserve Program grassland study[c]	Frequency (%) of cowbird parasitism (maximum number of cowbird eggs)[d]	Frequency (%) of multiple parasitism (parasitism intensity)[e]
Willow Flycatcher (*Empidonax traillii*)	SHRU	0/1	0/2	0	0
Least Flycatcher (*Empidonax minimus*)	OPWO		0/1	0	0
Say's Phoebe (*Sayornis saya*)	RESI	0/1		0	0
Western Kingbird (*Tyrannus verticalis*) ‡	OPTR	0/11	0/22	0	0
Eastern Kingbird (*Tyrannus tyrannus*) †	OPTR	0/36	2/83	1.7 (1)	0 (1.0 ± 0.0)
Loggerhead Shrike (*Lanius ludovicianus*) ‡	SHRU	0/5	0/1	0	0
Horned Lark (*Eremophila alpestris*)	GRAS	5/25	0/7	15.6 (3)	80.0 (2.0 ± 0.7)
Barn Swallow (*Hirundo rustica*)	RESI		0/1	0	0
House Wren (*Troglodytes aedon*)	OPWO	0/1		0	0
Marsh Wren (*Cistothorus palustris*)	WETL	0/2	0/5	0	0
Sedge Wren (*Cistothorus platensis*)	GRAS		0/3	0	0
American Robin (*Turdus migratorius*) ‡	OPWO	0/6	0/6	0	0
Gray Catbird (*Dumetella carolinensis*) ‡	SHRU	0/1		0	0
Northern Mockingbird (*Mimus polyglottos*) ‡	SHRU		0/1	0	0
Brown Thrasher (*Toxostoma rufum*) †	SHRU	0/10	1/16	3.8 (1)	0 (1.0 ± 0.0)
Sprague's Pipit (*Anthus spragueii*)	GRAS	0/1	0/1	0	0
Cedar Waxwing (*Bombycilla cedrorum*) ‡	OPWO		0/3	0	0
Yellow Warbler (*Dendroica petechia*)	OPWO	0/3	8/21	33.3 (1)	0 (1.0 ± 0.0)
Ovenbird (*Seiurus aurocapillus*)	WOOD	0/1		0	0
Common Yellowthroat (*Geothlypis trichas*)	WETL		2/17	11.8 (2)	25.0 (1.3 ± 0.5)
Spotted Towhee (*Pipilo maculatus*)	OPWO	0/3		0	0
Chipping Sparrow (*Spizella passerina*)	OPWO		0/1	0	0
Clay-colored Sparrow (*Spizella pallida*)	SHRU	3/13	20/183	11.7 (4)	43.5 (1.5 ± 0.7)
Brewer's Sparrow (*Spizella brewerii*)	SHRU		0/5	0	0
Field Sparrow (*Spizella pusilla*)	SHRU	0/3		0	0
Vesper Sparrow (*Pooecetes gramineus*)	GRAS	2/10	1/10	15.0 (4)	66.7 (2.3 ± 1.5)
Lark Sparrow (*Chondestes grammacus*)	GRAS	1/4	1/3	28.6 (3)	50.0 (2.0 ± 1.4)
Lark Bunting (*Calamospiza melanocorys*)	GRAS	4/9	14/84	19.4 (6)	38.9 (1.9 ± 1.4)
Savannah Sparrow (*Passerculus sandwichensis*)	GRAS	0/1	8/81	9.8 (3)	62.5 (1.8 ± 0.7)
Grasshopper Sparrow (*Ammodramus savannarum*)	GRAS	3/4	9/57	19.7 (2)	44.4 (1.4 ± 0.5)
Baird's Sparrow (*Ammodramus bairdii*)	GRAS	0/1	0/4	0	0
Henslow's Sparrow (*Ammodramus henslowii*)	GRAS		0/2	0	0
Le Conte's Sparrow (*Ammodramus leconteii*)	GRAS		3/12	25.0 (2)	33.3 (1.3 ± 0.6)
Song Sparrow (*Melospiza melodia*)	SHRU	0/2	4/15	23.5 (5)	75.0 (3.0 ± 1.8)
Swamp Sparrow (*Melospiza georgiana*)	WETL		1/2	50.0 (3)	100.0 (3.0 ± 0.0)
Chestnut-collared Longspur (*Calcarius ornatus*)	GRAS	2/20	0/6	7.7 (3)	50.0 (2.0 ± 1.4)

TABLE 2. (*Continued*)

Species [a]	Breeding habitat association[b]	Incidence of cowbird parasitism: North Dakota statewide study[c]	Incidence of cowbird parasitism: Conservation Reserve Program grassland study[c]	Frequency (%) of cowbird parasitism (maximum number of cowbird eggs)[d]	Frequency (%) of multiple parasitism (parasitism intensity)[e]
Dickcissel (*Spiza americana*)	GRAS		2/3	66.7 (2)	50.0 (1.5 ± 0.7)
Bobolink (*Dolichonyx oryzivorus*)	GRAS	0/1	15/77	19.2 (6)	53.3 (2.2 ± 1.6)
Red-winged Blackbird (*Agelaius phoeniceus*)	WETL	9/28	330/758	43.1 (8)	49.6 (1.9 ± 1.2)
Western Meadowlark (*Sturnella neglecta*) ‡	GRAS	4/6	5/50	16.1 (6)	100.0 (3.4 ± 1.6)
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	WETL	1/7	0/1	12.5 (1)	0 (1.0 ± 0.0)
Brewer's Blackbird (*Euphagus cyanocephalus*)	SHRU	0/7	12/29	33.3 (3)	58.3 (1.8 ± 0.8)
Common Grackle (*Quiscalus quiscula*)	OPTR	0/7	1/87	1.1 (1)	0 (1.0 ± 0.0)
Orchard Oriole (*Icterus spurius*)	OPWO	0/1	5/7	62.5 (2)	40.0 (1.4 ± 0.5)
American Goldfinch (*Carduelis tristis*)	SHRU	1/3	0/5	12.5 (1)	0 (1.0 ± 0.0)
Passerines	–	35/234	441/1668	25.0 (8)	49.4 (1.9 ± 1.2)
Nonpasserines [f]	–	0/117	1/630	<0.1 (1)	0 (1.0 ± 0.0)

[a] Species known to eject cowbird eggs are identified with "‡". Ejection status is based on information provided in Peer and Sealy (2004).

[b] Breeding habitat associations of passerine species defined as: GRAS: Grassland; WETL: Wetland; WOOD: Woodland; SHRU: Shrubland; OPTR: Open habitat with scattered trees or shrubs; OPWO: Open or semi-open deciduous woodland and edge; RESI: Residential (rural development, urban, human-made structures). Categories follow Igl and Johnson (1997).

[c] Number of nests parasitized / number of nests found.

[d] The overall frequency (%) of cowbird parasitism is the total number of parasitized nests (*100) divided by the total number of nests found (North Dakota statewide study and the CRP grassland study combined). The maximum number of cowbird eggs represents the greatest number of cowbird eggs found in a single nest of that species during both studies combined.

[e] The overall frequency (%) of multiple parasitism is the total number of nests containing more than one cowbird egg (*100) divided by the total number of parasitized nests found (North Dakota statewide study and the CRP grassland study combined). The average number of cowbird eggs per parasitized nest (± SD) is the sum of all individual cowbird eggs found in all parasitized nests in both studies divided by the total number of parasitized nests.

[f] Nonpasserine species (n = no. nests) include: Pied-billed Grebe (*Podilymbus podiceps*, n = 1), Red-necked Grebe (*Podiceps grisegena*; n = 1), American Bittern (*Botaurus lentiginosus*; n = 6), Canada Goose (*Branta canadensis*; n = 1), Gadwall (*Anas strepera*; n = 113), American Wigeon (*Anas americana*; n = 12), Mallard (*Anas platyrhynchos*, n = 123), Blue-winged Teal (*Anas discors*; n = 65), Northern Shoveler (*Anas clypeata*; n = 12), Northern Pintail (*Anas acuta*; n = 29), Canvasback (*Aythya valisineria*, n = 1), Redhead (*Aythya americana*; n = 3), Ring-necked Duck (*Aythya collaris*; n = 1), Lesser Scaup (*Aythya affinis*; n = 5), Northern Harrier (*Circus cyaneus*; n = 48), Swainson's Hawk (*Buteo swainsoni*, n = 3), Ferruginous Hawk (*Buteo regalis*; n = 2), Ring-necked Pheasant (*Phasianus colchicus*; n = 35), Sharp-tailed Grouse (*Tympanuchus phasianellus*, n = 14), Wild Turkey (*Meleagris gallopavo*; n = 1), Sora (*Porzana carolina*; n = 2), American Coot (*Fulica americana*; n = 10), American Avocet (*Recurvirostra americana*, n = 1), Upland Sandpiper (*Bartramia longicauda*; n = 7), Wilson's Snipe (*Gallinago delicata*; n = 2), Wilson's Phalarope (*Phalaropus tricolor*; n = 5), Mourning Dove (*Zenaida macroura*, n = 233), Black-billed Cuckoo (*Coccyzus erythropthalmus*; n = 2), Short-eared Owl (*Asio flammeus*; n = 5), and Common Nighthawk (*Chordeiles minor*; n = 4).

TABLE 3. Contents of parasitized passerine nests found incidentally during breeding bird surveys in two studies in the northern Great Plains, 1990–2006.

Number of host eggs or nestlings per nest	Number of Brown-headed Cowbird eggs or nestlings per nest								Total number of nests
	1	2	3	4	5	6	7	8	
0	37	21	8	3	5	1	1	1	77
1	40	23	9	6	2	3			83
2	50	41	14	5	2	2			114
3	58	37	18	4	1	2			120
4	45	13	3	3					64
5	10	1	5	1					17
6	1								1
Total number of nests	241	136	57	22	10	8	1	1	476

TABLE 4. Yearly variation of Brown-headed Cowbird parasitism in passerine nests (all species combined) found incidentally during breeding bird surveys in two studies in the northern Great Plains, 1990–2006.

Year	Total number of nests	Frequency of cowbird parasitism (%)	Frequency of multiple parasitism (%)	Parasitism intensity (mean ± SD)[a]	Distribution of cowbird eggs in parasitized nests[b]
1990	57	29.8	35.3	1.6 ± 0.9	random
1991	52	15.4	50.0	1.8 ± 0.9	random
1992[c]	181	12.7	52.2	2.2 ± 1.5	random
1993[c]	90	20.0	55.6	2.2 ± 1.6	random
1994	41	19.5	62.5	1.9 ± 0.8	random
1995	32	18.8	33.3	1.3 ± 0.5	random
1996	20	0	0	–	–
1997	42	16.7	42.9	1.6 ± 0.8	random
1998	96	24.0	60.9	2.0 ± 1.4	random
1999	96	25.0	62.5	2.4 ± 1.6	random
2000	75	25.3	57.9	1.9 ± 1.2	random
2001	129	35.7	34.8	1.5 ± 1.0	random
2002	184	34.8	50.0	1.9 ± 1.1	random
2003	189	24.9	46.8	1.8 ± 1.2	random
2004	234	29.9	57.1	1.8 ± 0.8	random
2005	231	23.8	36.4	1.7 ± 1.4	non-random
2006	153	26.8	56.1	1.9 ± 1.2	random
Mean ± SE	111.8 ± 17.2	22.6 ± 2.1	46.9 ± 3.8		

[a]Mean number of cowbird eggs or nestlings per parasitized nest.
[b]Random distribution of cowbird eggs in parasitized nests was evaluated using a zero-truncated Poisson distribution model (Lindsey 1997). Random distribution of cowbirds eggs indicated that female cowbirds did not discriminate among parasitized nests and that the proportion of nests with 1, 2, 3, 4, ...*i* cowbird eggs approximated a Poisson distribution. Non-random distribution indicated that the random distribution model was rejected ($P < 0.01$).
[c]Data for the North Dakota statewide study and the CRP study were combined for 1992 and 1993.

Not including nests of the Red-winged Blackbird, our sample of passerine nests from the two studies included mostly nests of grassland-nesting (e.g., Western Meadowlark) and edge-nesting (e.g., Yellow Warbler) species and very few nests of cavity-nesting (e.g., House Wren) or woodland-interior (e.g., Ovenbird) species (Table 2). We found 482 nests of 15 passerine species that typically nest in grasslands. Overall, the parasitism rate of grassland bird nests was low-to-moderate (16.4%). We found 602 nests of 23 passerine species that typically nest in habitats characterized by woody vegetation (i.e., woodland, shrubland, open habitat with scattered trees or shrubs, open or semi-open deciduous woodland, and edge). The parasitism rate of bird species associated with woody vegetation was low (9.5%).

Of the 45 passerine species for which nests were found, nine species are known to eject cowbird eggs (Table 2; Peer and Sealy 2004). Of the 257 nests of these nine ejector species that we found, 12 (4.7%) contained cowbird eggs. The overall parasitism rate for nests of all non-ejector (i.e., acceptor) passerine species combined was 28.2% ($n = 1645$). In addition, Yellow Warblers often bury the contents of parasitized nests under a new nest floor (Clark and Robertson 1981; Burgham and Picman 1989). Eight of 24 (33.3%) Yel-

TABLE 5. Weekly variation of Brown-headed Cowbird parasitism in passerine nests (all species combined) found incidentally during breeding bird surveys in two studies in the northern Great Plains, 1990–2006.

Weekly period[a]	Total number of nests	Frequency of cowbird parasitism (%)	Frequency of multiple parasitism (%)	Parasitism intensity (mean ± SD)[b]	Distribution of cowbird eggs in parasitized nests[b]
April IV	5	0	0	–	–
May I	0	0	0	–	–
May II	6	0	0	–	–
May III	11	9.1	100.0	4.0 ± 0.0	
May IV	91	11.0	60.0	2.6 ± 2.0	random
June I	274	19.7	50.0	2.1 ± 1.5	random
June II	4020	37.3	51.3	1.8 ± 1.1	non-random
June III	421	27.8	53.0	1.9 ± 1.1	random
June IV	454	20.9	41.1	1.6 ± 0.9	non-random
July I	162	21.0	50.0	2.0 ± 1.4	random
July II	39	23.1	33.3	1.4 ± 0.7	random
July III	37	16.2	50.0	2.2 ± 1.6	random
Mean ± SE	158.5 ± 51.9	20.7 ± 2.8[c]	54.3 ± 6.2[c]	–	–

[a]To evaluate changes in cowbird parasitism within the breeding season, each month was divided into four, roughly weekly, periods (week I = 7 days, week II = 8 days, week III = 7[8] days, and week IV = 8 days) (sensu Orians et al. 1989).
[b]See Table 4 for explanation.
[c]Mean includes third week in May to third week in July (i.e., weeks with cowbird parasitism).

low Warbler nests each contained a single cowbird egg. During the CRP study, buried (but visible) cowbird eggs were observed in two Yellow Warbler nests (one in Kidder County, North Dakota, on 27 June 2003 and one in Eddy County, North Dakota, on 25 June 2005) and one Clay-colored Sparrow nest (McPherson County, South Dakota, on 13 June 2006).

Parasitized nests of passerines were found in 16 of the 17 years (Table 4). No parasitized nests were found in 1996, which also is the year that we found the fewest number of active passerine nests. Excluding 1996, annual parasitism rates ranged from 12.7 to 35.7% and averaged 22.6% (Table 4). The average annual rate of multiple parasitism was 46.9%. The zero-truncated Poisson distribution model for parasitized nests was rejected in one (i.e., 2005) of the 16 years in which parasitized nests were found.

In both studies combined, passerine nests were found in 11 of 12 weekly periods from the last week of April through the third week of July (Table 5). Eleven passerine nests were found in two of the three weeks before the first cowbird egg was found (i.e., before the third week in May), although cowbirds were recorded in each of those three weeks (Igl and Johnson, unpublished data). In the North Dakota statewide study, we found active nests between 27 April and 20 July, parasitized nests between 20 May and 18 July, and multiply parasitized nests between 20 May and 18 July. In the CRP grassland study, we found active nests between 22 May and 9 July, parasitized nests between 29 May and 9 July, and multiply parasitized nests between 29 May and 9 July. During both studies, nonparasitized and parasitized nests were found largely between late May and early July, which corresponds with the peak breeding periods of most passerine species in the northern Great Plains, including the Brown-headed Cowbird (Stewart 1975; Igl and Johnson 1997; Tallman et al. 2002). After the third week in May, weekly parasitism rates ranged from 9.1 to 37.3% and averaged 20.7%; the highest parasitism rates were found in the second and third weeks of June (Table 5). The average weekly rate of multiple parasitism was 54.3%. The zero-truncated Poisson distribution model for parasitized nests was rejected in two (i.e., second and fourth week of June) of eight weekly periods.

In the CRP grassland study, parasitized and multiply parasitized nests of passerines were found in all nine counties (Table 6). Cowbird parasitism of passerine nests was low in Fallon County in southeastern Montana (5.8%) and Grant County in western Minnesota (9.3%). Parasitism rates were low-to-moderate in Butte County in western South Dakota (12.8%) and Sheridan County in northeastern Montana (11.6%), and moderate in Hettinger (29.9%), Kidder (25.3%), and Eddy (23.8%) counties in North Dakota and Day County in northeastern South Dakota (28.9%). Heavy parasitism was found in McPherson County in north-central South Dakota (51.5%). The frequency of multiple parasitism was moderate in Butte (21.4%) and Day counties in South Dakota (39.8%) and Fallon County, Montana (25%), and moderate-to-heavy to heavy in the other six counties (range: 42.9–58.7%). The zero-truncated Poisson distribution model for parasitized nests was rejected in one (i.e., Day County, South Dakota) of the nine counties (Table 6). Nests within the counties of highest female cowbird abundance experienced higher frequencies of cowbird parasitism ($R^2 = 0.64$, $F = 12.65$, $P = 0.0093$) than those found in counties with the lowest female cowbird abundance (Figure 3). The quadratic term for cowbird densities was nonsignificant ($P = 0.62$) and was not included in the final model.

TABLE 6. Regional variation in Brown-headed Cowbird parasitism in passerine nests (all species combined) found incidentally during breeding bird surveys in Conservation Reserve Program grassland fields in nine counties in the northern Great Plains, 1990–2006.

County	Total number of nests	Frequency of cowbird parasitism (%)	Frequency of multiple parasitism (%)	Parasitism intensity (mean ± SD)[a]	Distribution of cowbird eggs in parasitized nests[a]
Butte, South Dakota	109	12.8	21.4	1.2 ± 0.4	random
Day, South Dakota	322	28.9	39.8	1.6 ± 1.1	non-random
Eddy, North Dakota	172	23.8	46.3	1.8 ± 1.1	random
Fallon, Montana	69	5.8	25.0	1.3 ± 0.5	random
Grant, Minnesota	151	9.3	42.9	1.5 ± 0.7	random
Hettinger, North Dakota	211	29.9	58.7	2.2 ± 1.5	random
Kidder, North Dakota	332	25.3	45.2	1.7 ± 0.9	random
McPherson, South Dakota	233	51.5	59.2	2.0 ± 1.1	random
Sheridan, Montana	69	11.6	50.0	2.1 ± 1.3	random

[a]See Table 4 for explanation.

In the CRP grassland study, cowbird densities, total breeding bird densities, and total breeding bird richness were lowest in the southwestern counties (Butte County, South Dakota, and Fallon County, Montana) and highest in counties near the center of the cowbird's breeding bird range. There was a positive relationship between female cowbird densities and all measures of avian abundance and richness. That is, female cowbird densities increased with increasing density and richness at all levels of the avian community (Table 7). Breeding bird density for all bird species ($R^2 = 0.72$) was a better predictor of cowbird abundance than the other four levels of avian densities (Table 7, Figure 4a). Breeding bird richness for all bird species ($R^2 = 0.69$) was a better predictor of cowbird abundance than the other three levels of avian richness (Table 7, Figure 4b). There was only a weak suggestion that cowbirds use, as a settlement cue, the number of passerines species known to have raised cowbird young ($P = 0.115$).

During breeding bird surveys in both studies, observers noted 586 instances of adult passerines provisioning food to individual fledglings, of which only 26 (4.4%) instances involved hosts feeding cowbird fledglings. These 26 observations occurred between 4 June and 7 July and involved eight host species: Clay-colored Sparrow (5 cases), Grasshopper Sparrow (1 case), Le Conte's Sparrow (1 case), Savannah Sparrow (6 cases), Song Sparrow (4 cases), Brewer's Blackbird (2 cases), Red-winged Blackbird (5 cases), and Orchard Oriole (2 cases). These eight species accounted for 83.6% of the total cowbird parasitism in these two studies (Table 2). Although we cannot establish conclusively the true foster-parentage of these fledgling cowbirds, we did not observe any non-parasitized species (i.e., species whose nests were not parasitized during the two studies) feeding cowbird fledglings during the two studies.

Discussion

Brown-headed Cowbirds parasitize nests of a wide variety of host species (Friedmann 1963; Lowther 1993), including some inappropriate hosts. As in other studies (Ortega 1998), we found almost no cowbird parasitism of nonpasserine nests. Most nonpasserines are considered unsuitable hosts, and their nests usually are avoided by Brown-headed Cowbirds (Rothstein and Robinson 1998). Although the only parasitized nonpasserine, an Upland Sandpiper, was clearly an unsuitable host (i.e., a large-bodied host with precocial, nidifugous young), several other studies have documented cowbird eggs in Upland Sandpiper nests (Higgins and Kirsch 1975; Faanes and Lingle 1995*; Davis and Duncan 1999).

Our overall frequency of cowbird parasitism (25%) for passerine species was within the range that Ortega (1998) considered moderate (20–40%). This overall rate seems low given that cowbird densities are highest in the northern Great Plains (Sauer et al. 2005*) and that cowbirds are more abundant than many of their common hosts in this region (Igl and Johnson 1997; Igl et al. 1999). However, our combined parasitism rate is based on nests from two studies, an extensive region, 17 years, and numerous passerine species, including several species that ostensibly have developed behavioral defenses against cowbird parasitism (see below). After we excluded nests of ejector species, our overall parasitism rate remained moderate (28.2%). Some studies in this region have found higher combined rates of cowbird parasitism than those reported herein. For example, Koford et al. (2000) found an overall parasitism rate of 40.3% for passerines nesting in seeded and native grasslands and cropland in North Dakota and Minnesota, and Davis and Sealy (2000) found an overall rate of 32.6% for species nesting in grasslands in southwestern Manitoba. In both of these studies, some individual species experienced moderate-to-heavy levels of cowbird parasitism (e.g., >40% parasitism for Western Meadowlarks in both studies). Robinson and Smith (2000) suggested that some of these commonly cited reports of high parasitism rates from the northern Great Plains might not be representative of this region. Indeed, some recent reviews of geographic patterns of cowbird parasitism (e.g., Peer et al. 2000; Chace et al. 2005) focused on the extreme

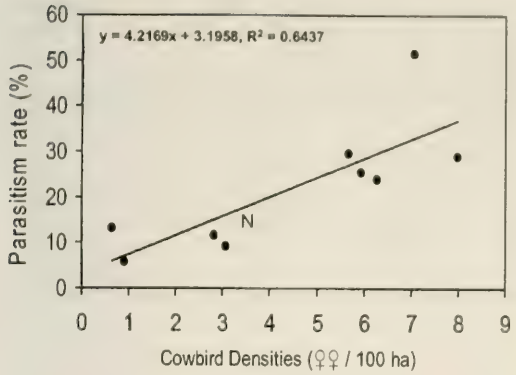

FIGURE 3. Relationship between female cowbird densities and the percentage of the total number of passerine nests that were parasitized in Conservation Reserve Program grasslands in North Dakota, South Dakota, Minnesota, and Montana, 1990–2006. The data from the North Dakota (N) statewide study were included for comparison (1992 and 1993 were averaged).

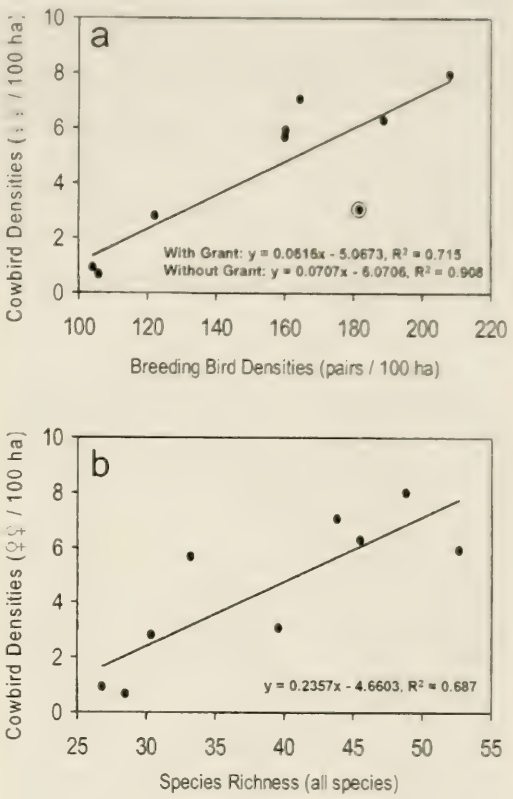
a
With Grant: y = 0.0616x - 5.0673, R² = 0.715
Without Grant: y = 0.0707x - 6.0706, R² = 0.908
Breeding Bird Densities (pairs / 100 ha)
b
y = 0.2357x - 4.6603, R² = 0.687
Species Richness (all species)

FIGURE 4. Relationship between (a) mean female cowbird densities and average densities of all other breeding bird species, and (b) mean female cowbird densities and mean species richness within the breeding bird community (excluding cowbirds) in Conservation Reserve Program (CRP) grasslands in North Dakota, South Dakota, Minnesota, and Montana, 1990–2006. The circle in Figure 4a indicates a potential outlier, Grant County in Minnesota, which is discussed in the text.

cases of parasitism in the northern Great Plains (e.g., Linz and Bolin 1982; Davis and Sealy 2000; Koford et al. 2000). There are many less-cited studies of cowbird parasitism (see Shaffer et al. 2003) with low-to-moderate rates of cowbird parasitism in this region (e.g., Hill and Sealy 1994; Granfors et al. 2001; Davis 2003; Woolfenden et al. 2004). For example, in Manitoba, Davis (2003) found an overall parasitism rate of 19.9% for six grassland species in southern Saskatchewan over a 5-year period.

Although our overall rate of cowbird parasitism was 25%, we did find higher rates of parasitism in some years (e.g., 35.7% in 2001), weeks (e.g., 37.3% in the second week of June), counties (e.g., 51.5% in McPherson County, South Dakota), and individual species (e.g., 43.1% for the Red-winged Blackbird). The results from our studies can serve as a reminder that cowbird parasitism rates are not constant across space or time (i.e., among years or within a breeding season) and that cowbirds differentially parasitize hosts within the same habitats. Differences in parasitism levels among studies in the northern Great Plains may simply reflect variation among species, regions, habitats, or years. For example, Davis and Sealy's (2000) overall parasitism rate of 32.6% was based on data collected at three study sites over two years; parasitism rates were low-to-moderate at two of the study sites (18 and 20%) and heavy at the third study site (67%). We echo Hahn and Hatfield's (1995) caveat that patterns of cowbird parasitism are complex and variable, and that field studies of cowbird parasitism would be more effective if they were long-term, community-wide studies set in strategically chosen communities in different regions.

Our nest data were slightly unorthodox compared to nest data from many other studies. We located all of our nests fortuitously and observed each nest only once. Any cowbird eggs ejected before our surveys, any nests abandoned before our surveys, any cowbird eggs buried completely in the nest lining, and any cowbird eggs added or removed after our brief observations were not recorded in our studies, and thus our frequencies of cowbird parasitism should be considered minimal estimates. These limitations, however, are not unique to our data but rather are common features of all studies of cowbird parasitism that do not involve cameras, because most nests are not monitored continuously throughout the nesting cycle but rather are visited at relatively fixed intervals (e.g., every 2–4 days) for relatively brief periods of time (e.g., less than a few minutes). Even systematic nest searches are neither incessant nor comprehensive, but rather occur at fixed intervals (e.g., Koford et al. 2000; Davis 2003; Winter

TABLE 7. Five levels of avian abundance (density) and richness (number of species) that female Brown-headed Cowbirds could use as proximate cues for settlement in Conservation Reserve Program grassland fields in nine counties in the northern Great Plains, 1990–2006. Linear regression analyses were performed to examine the relationship between female cowbird densities and each different subset of avian abundance and richness at the five levels of the avian community (also see Figure 4).

Level of avian community[a]	Breeding bird density			Number of breeding species		
	R^2	F	*P*	R^2	F	*P*
All breeding birds	0.72	17.53	0.004	0.69	15.56	0.006
All passerines	0.63	12.02	0.011	0.40	4.65	0.068
All passerines that have raised cowbirds	0.66	13.64	0.008	0.32	3.25	0.115
All passerines that are non-ejectors	0.62	11.39	0.012	0.38	4.32	0.076
Preferred host (Red-winged Blackbird)	0.54	8.35	0.023	–	–	–

[a] Excluding cowbirds.

et al. 2004). In addition, many studies that use systematic nest searches also include a fortuitous component to their nest searching methodology (e.g., Koford et al. 2000; Davis 2003). Thus, nearly all estimates of cowbird parasitism in the literature could be considered minimal estimates.

In our two studies, female cowbirds did not avoid laying eggs in previously parasitized nests. Nearly one-half of the parasitized nests in our two studies contained more than one cowbird egg, with the average parasitized nest containing about two cowbird eggs. The assumption that female cowbirds laid eggs randomly in parasitized nests could only be rejected in two of eight weekly periods, one of 16 years, and one of nine counties in the CRP grassland study. Deviations from a random Poisson distribution were likely related to a greater number of nests with multiple cowbird eggs or nestlings than would be expected by chance. Multiple parasitism has been widely documented in nests parasitized by the Brown-headed Cowbird (McLaren et al. 2003). Although multiple parasitism can vary by region or host species, it typically occurs in about one-third of all reported cases of cowbird parasitism (Friedmann 1963; Lowther 1993; Johnsgard 1997; Ortega 1998) and seems to be more common in nests of larger hosts (Lorenzana and Sealy 1999; Trine 2000). Little is known about the factors that might influence multiple parasitism, but some mechanisms have been proposed or investigated. For example, multiple parasitism might occur if (1) a female cowbird exhibits host preference (Smith and Myers-Smith 1998), (2) there is a high ratio of female cowbirds to host nests (McGeen 1972), (3) there is a shortage of alternative host nests (Smith and Myers-Smith 1998), or (4) an inexperienced and nonselective female makes a poor host choice (McLaren et al. 2003). Cowbird hosts in the Great Plains seem to be particularly vulnerable to multiple parasitism (e.g., Elliott 1978; Davis and Sealy 2000; this study), which may reflect higher densities of cowbirds (Elliott 1977; Ortega 1998) or lower densities of available or suitable hosts (Robinson and Smith 2000).

We likely underestimated the frequency of cowbird parasitism of those species that eject or bury cowbird eggs or that abandon parasitized nests (Ortega 1998). Less than 5% of the nests of ejector species in the two studies contained cowbird eggs, which was much lower than the overall parasitism rate (28.2%) for acceptor species. Ejection of cowbird eggs by a host is an effective anti-parasite strategy among some North America passerines (Ortega 1998; Peer and Sealy 2004), especially among edge-nesting passerines that are common in the northern Great Plains (Igl and Johnson 1997; Table 1). Even within acceptor species, however, some individuals are prone to abandon parasitized nests and then re-nest (Lorenzana and Sealy 1999). Hosoi and Rothstein (2000) showed that the frequency of desertion of parasitized nests was higher in non-forest than forest species and suggested that increased nest desertion was an evolved response to cowbird parasitism. Among small-sized hosts, nest desertion seems to be a common response to parasitism or defense against parasitism (Ortega 1998). Many species that breed in the northern Great Plains are known to abandon their nests occasionally as a result of parasitism or cowbird removal of host eggs (e.g., Ortega 1991; Hosoi and Rothstein 2000), including some grassland and shrub-grassland species, although the frequency of abandonment may be quite low (Sealy 1999; Davis and Sealy 2000).

The Red-winged Blackbird was the third most abundant species observed in both of our studies. Despite its aggressive nest-defense behaviors against cowbirds and its colonial-nesting tendencies (Freeman et al. 1990), the Red-winged Blackbird was the most commonly parasitized species in the two studies (43.1% parasitism, 49.6% multiple parasitism, 71.2% of all cases of parasitism) and appears to be a preferred cowbird host in the northern Great Plains. Our data support Hanka's (1979) contention that cowbirds may show a phylogenetic preference for Red-winged Blackbirds and other Icterine species (e.g., Brewer's Blackbird, Orchard Oriole; Table 2) in the cowbird's range. Linz and Bolin (1982) and Koford et al. (2000) reported similar parasitism rates (42 and 43%, respectively) for Red-winged Blackbirds in this region. In the eastern portion of the cowbird's range, Red-winged Blackbirds are rarely parasitized (e.g.,

Hahn and Hatfield 1995). Although we categorized the Red-winged Blackbird as a wetland species (Table 2; Igl and Johnson 1997), many of the red-wing nests that we found during the CRP grassland study were scattered in upland habitats (grassland, shrub-grassland), where group defense is generally lower (Robertson and Norman 1977; Ortega 1991) and parasitism rates are generally higher (Robertson and Norman 1976; Krapu 1978). Several host species are known to avoid or reduce parasitism by acting aggressively toward cowbirds (Robertson and Norman 1976, 1977), but aggression is not always an effective host defense against cowbird parasitism, especially in habitats in which host densities are low because cowbirds may use host aggression (Robertson and Norman 1977) or vocalizations (Clotfelter 1998) to locate nests. Nonetheless, the Red-winged Blackbird is one of a few species reported to reduce parasitism by mobbing (Freeman et al. 1990; Chace et al. 2005).

The presence of Red-winged Blackbirds may be a double-edged sword for other passerines nesting in the same habitats, such as CRP grasslands. Red-winged Blackbirds are conspicuous breeding birds in CRP grasslands and thus might increase parasitism in nests of other species. Barber and Martin (1997) found that a conspicuous, co-occurring species in a breeding bird community can increase the risk of cowbird parasitism on alternative host species. Alternatively, other species may benefit from nesting near Red-winged Blackbirds if (1) the defensive behavior of blackbirds toward cowbirds reduces cowbird activity in the area, or (2) higher cowbird parasitism of blackbird nests reduces parasitism pressure on other species. Fretwell (1972) noted higher rates of cowbird parasitism in Dickcissel nests that were built near Red-winged Blackbird nests, whereas Clark and Robertson (1979) found the opposite for Yellow Warblers. Woolfenden et al. (2004) speculated that Red-winged Blackbirds might have increased the risk of parasitism on Yellow Warblers in their Manitoba study sites. The influence of Red-winged Blackbird presence and abundance on cowbird parasitism rates of other species requires further study.

Mayfield (1965b) suggested that grassland birds may have evolved defenses against brood parasitism because of their long evolutionary history of co-occurrence with the Brown-headed Cowbird in the Great Plains. To date, however, the species that have shown the strongest anti-parasite behaviors (i.e., egg ejection) have not been the grassland species but rather have been the species associated with woody vegetation (Peer and Sealy 2004, Table 2). Our overall rate of cowbird parasitism for grassland bird nests (16.4%) was much lower than those reported in some studies (e.g., Elliott 1978 [57.7%]; Davis and Sealy 2000 [32.6%]; Jensen and Finck 2004 [42.9%]) but comparable to or higher than those reported in other studies (e.g., Strausberger and Ashley 1997 [0%]; Kershner and Bollinger 1998 [1.7%]; Robinson et al. 2000 [7.8%]; Granfors et al. 2001 [14%]; Davis 2003 [19.9%]; Winter et al. 2004 [6.7%]). Nonetheless, we found a higher frequency of parasitism in nests of grassland species than in nests of species that nest in edge and woodland habitats (9.5%). In contrast to our results, in Illinois, Robinson et al. (1999, 2000) and Strausberger and Ashley (1997) found a higher frequency of parasitism in species nesting in edge and woodland habitats than in nests of grassland species. Although the difference between the two regions for grassland birds is consistent with the pattern that cowbird parasitism declines with distance from the center of the cowbird's range in the northern Great Plains, the difference for species associated with woody vegetation is contrary to this generalization. Again, these patterns emphasize the complexity and variability of cowbird parasitism in North America (Hahn and Hatfield 1995). Robinson and Smith (2000) and others (Peer et al. 2000; Jensen and Finck 2004) have suggested that the higher levels of parasitism in grasslands in the Great Plains than those in the Midwest might reflect the near absence of large forested areas, where more tolerant hosts can absorb cowbirds and cowbird parasitism from grasslands. Seemingly, our data support this contention. In our most-forested county in the CRP grassland study (Grant County in west-central Minnesota; Igl and Johnson, unpublished data), the density of female cowbirds (and cowbird parasitism) was much lower than would be expected given the density of breeding birds in the avian community (Figure 4a). Moreover, Minnesota typically is lumped with midwestern states rather than with Great Plains states. In the other eight counties, there are few, if any, large forested areas that could absorb cowbird parasitism from the open grasslands. Trees and shrubs in these eight counties occur largely in small, often linear, patches, where cowbird egg ejectors (e.g., kingbirds, thrashers, catbirds, robins) dominate the breeding bird community. The low parasitism rates of edge and woodland species in our study may reflect the predominance of ejector species in woody habitats in the northern Great Plains (Igl and Johnson 1997) and the avoidance by cowbirds of a habitat that may contain many less-tolerant hosts (Sealy and Bazin 1995).

In Illinois, Peer et al. (2000) recently found that Western Meadowlarks rejected (i.e., ejected or damaged) 78% of artificial and real cowbird eggs experimentally added to nests. In contrast, in the northern Great Plains, some Western Meadowlark populations are moderately to heavily parasitized (23–67%: Davis and Sealy 2000; 19–47%: Koford et al. 2000), and the species often experiences extreme levels of multiple parasitism in this region (Davis and Sealy 2000; Davis 2003; this study). It is unclear why some meadowlark individuals or populations experience heavy or intense parasitism (e.g., average of 3.4 and 3.1 cowbird eggs per parasitized nest in this study and Davis and Sealy 2000, respectively), whereas others apparently experience little or none. Davis and Sealy (2000) suggested that the apparent geographic variation in parasitism levels in Western Meadowlark populations in

the northern Great Plains and elsewhere might reflect differences in the size of suitable grassland patches and the availability of other host species in the community. Peer et al. (2000) suggested that geographic differences in parasitism levels in the northern Great Plains and the Midwest might reflect geographic variation in egg rejection by Western Meadowlarks. Egg rejection behavior in the Western Meadowlark should be tested in more geographic locations or landscapes to resolve these issues. Moreover, the Western Meadowlark and its congener, the Eastern Meadowlark (*Sturnella magna*), use a similar tactic to destroy eggs or clutches of other birds (Creighton and Porter 1974; Schaef and Picman 1988; Picman 1992). The function of this egg-destroying behavior has been speculative (e.g., predation, interference competition for limited resources), but in view of the similarities (e.g., egg removal, puncture) between this egg-destroying behavior at nests of other birds and cowbird egg ejection at their own nests, experiments are needed to evaluate the relationship between general egg destruction and cowbird egg rejection by meadowlarks.

In our CRP grassland study, female cowbird densities varied greatly among the nine counties in the northern Great Plains, and rates of cowbird parasitism were higher in the counties in which densities of female cowbirds were higher. Our results support the interpretation of Miles and Buehler (2000) and Chace et al. (2005) that female cowbird densities are a reasonable predictor of the frequencies of cowbird parasitism. Our results also support the contention that cowbird parasitism declines with distance from the center of the cowbird's range, although on a smaller scale (Hoover and Brittingham 1993; Smith and Myers-Smith 1998; Thompson et al. 2000).

Few studies have evaluated the relationship between cowbird abundance and parasitism levels using cowbird and nest data collected concurrently at the same study sites over a large region (e.g., Robinson et al. 2000; Jensen and Cully 2005a, 2005b). Large-scale evaluations of this relationship typically have relied on data from unconnected sources, such as abundance data from the North American Breeding Bird Survey (BBS) and nest data from the Cornell Laboratory of Ornithology or from multiple studies (e.g., Hoover and Brittingham 1993; Basili 1997; Smith and Myers-Smith 1998; Herkert et al. 2003). Most evaluations of this relationship have focused on single species (Hoover and Brittingham 1993; Basili 1997; Smith and Myers-Smith 1998; Herkert et al. 2003). Nonetheless, many studies have found similar positive relationships between cowbird densities and cowbird parasitism levels. For example, Basili (1997) and Herkert et al. (2003) showed that cowbird densities on BBS routes were positively related to frequencies of cowbird parasitism of Dickcissel nests from multiple studies across several states. Jensen and Cully (2005a,b) found a similar, positive relationship between female cowbird densities and parasitism levels of Dickcissel nests at eight study sites in Kansas and Oklahoma. In a meta-analysis of nest and cowbird data from six studies from four midwestern states, Thompson et al. (2000) similarly found that cowbird abundance and parasitism levels of multiple species were positively correlated across study areas. In contrast, Woolfenden et al. (2004) found that female cowbird abundance was not related to parasitism frequency among three species in an avian community in Manitoba, and Robinson et al. (2000) found that the percentage of nests parasitized was not related to cowbird abundance in multiple forest sites across Illinois.

In CRP grasslands, we also found a positive relationship between cowbird abundance and all five levels of the avian community, including all avian species, all passerine species, all passerines that are non-ejectors, all passerines known to raise cowbird young, and a single, preferred host (i.e., Red-winged Blackbird). The abundance and richness of all avian species were the strongest predictors of cowbird abundance, which suggests that cowbirds might use the overall breeding bird community as a settlement cue for optimal areas to breed rather than more specific passerine or host categories (e.g., all passerines that are known to have raised cowbird young). The number of individuals and the number of species represent different components of a cowbird's breeding resource. The presence of more individuals and more species with different breeding chronologies ensures a larger number of potential hosts within the breeding bird community throughout the cowbird's breeding season (Farmer 1999). Although we evaluated these relationships using only data from the CRP grassland study, cowbirds also might use other cues (e.g., vegetation or landscape factors) as an indicator of the richness or abundance of the avian community (Chace et al. 2005).

Chace et al. (2005) tabulated 16 published studies and one unpublished study that evaluated the relationship between different measures of the avian community and cowbird abundance or occurrence. As with our results, many studies found positive relationships between cowbirds and different measures of avian densities and richness. To our knowledge, Farmer (1999) is the only other published study to have evaluated multiple host and avian community measures using both abundance and richness data. Farmer (1999) found positive relationships for nearly every level of the avian community, including abundance and richness categories. Because host species are necessary for cowbirds to be reproductively successful, most studies have evaluated these relationships at the host level. Results of such evaluations have been inconsistent. Moreover, comparisons among studies using host categories are difficult because a variety of definitions of host communities were used (Chace et al. 2005). For example, Thompson et al. (2000) found that cowbird abundance was significantly correlated with host abundance (i.e., hosts included species that bred on the study area and accepted cowbird eggs), whereas Robinson et al. (2000)

found no relationship between cowbird abundance and host abundance (i.e., hosts included species that accept cowbird eggs regularly but excluding cavity nesters, cowbird egg ejectors, and large species). Evans and Gates (1997) found that cowbird abundance was positively related to the abundance of all avian species combined, but the relationship was non-significant for richness of all avian species and richness and abundance of host species (i.e., known cowbird hosts).

In summary, our data show that, even within the northern Great Plains, there is considerable variation in parasitism rates among species and across space and time. Our results demonstrate that parasitism rates overall are moderate in the northern Great Plains, although some individual species, counties, years, and weeks experience heavier rates of parasitism or multiple parasitism than others. Our study is one of the first to show a strong, positive relationship between regional cowbird abundance and nest parasitism rates using both cowbird abundance and nest data collected at the same study sites. We also found a clear, positive relationship between female cowbird densities and the overall breeding bird communities in CRP grasslands in the northern Great Plains. More studies are needed to determine if these relationships hold elsewhere in the northern Great Plains with different host communities or within other habitats.

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Wolf, *Canis lupus*, Behavior in Areas of Frequent Human Activity

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We report incidental observations of Wolves (*Canis lupus*) tolerating human activity in central Wisconsin. Three monitored packs raised pups in close proximity to varying levels of human activity. Wolf pups were raised <350m from rearing pens of the endangered Whooping Crane (*Grus americana*), which saw daily human activity. One pack used cornfields as rendezvous sites within 175 m of a maintenance shed visited regularly by workers. Another pack centered their activities along a well-traveled state highway using both the verge and the road center for activity. Aerial locations of 10 yearling and adult dispersing Wolves were plotted to evalute human densities in natal territories relative to dispersal and post-dispersal territories. Township densities ($\bar{\chi}$ = 9.02 humans/km^2, SE = 4.015) and residential densities ($\bar{\chi}$ = 5.59 housing units/km^2, SE = 2.12) in natal pack territories were significantly greater (P <.01) for dispersal and post-dispersal township densities ($\bar{\chi}$ = 43.98 humans/km^2, SE =7.37) and residence densities ($\bar{\chi}$ = 23.12 housing units/km^2, SE =3.49). Furthermore, a pup negotiated the densely populated region of northern Illinois and dispersed from central Wisconsin to east-central Indiana, a distance of at least 690 km. As Wolves live in closer proximity to humans, living in areas of higher township and residential densities, they can be expected to be more habituated to people, increasing the probability of human/Wolf conflicts.

Key Words: Wolf, *Canis lupus*, pups, humans, habituation, behavior, Wisconsin.

Historically, Gray Wolves (*Canis lupus*) were one of the most widely distributed land mammals in North America inhabiting all regions except arid deserts (Young 1944; Mech 1970; Mech and Boitani 2003). However, human settlement and persecution restricted Wolves to northern forested regions and eventually the only substantial population within the lower 48 states occurred in northern Minnesota (Mech 1970).

Under the protection of the federal Endangered Species Act of 1973, Wolves have returned to some areas within their historical range (Mech 1995). They began recolonizing Wisconsin in the mid-1970s (Mech and Nowak 1981; Thiel and Welch 1981; Wydeven et al. 1995). Wolves have since repopulated much of northern Wisconsin and an isolated area in the central part of the state referred to as the Central Forest Region (CFR). In 1999, the Wisconsin Department of Natural Resources (WDNR) downlisted the Wolf from an endangered to a threatened species (WDNR 1999*). Wolves continued to surpass target recovery levels. In April 2003, the U.S. Fish and Wildlife Service proposed to delist the Eastern Distinct Population Segment of Gray Wolf, which includes Wisconsin (Federal Register 2003*).

Wolves initially recolonized areas in Wisconsin with significantly lower road densities ($\bar{\chi}$ = 0.23 km/km^2) and human densities ($\bar{\chi}$ = 1.52 people/ km^2) (Mladenoff et al. 1995). As recovery progresses, Wolves are demonstrating an increasing tolerance to human activity throughout the upper Great Lakes region, including Wisconsin (Thiel et al. 1998). In recent years, Wolves have denned near active sphagnum moss drying sites, occupying homesites inside artillery impact zones on military bases, crossed four lane highways and large expanses of non-forested areas, and bypassed major U.S. cities (Licht and Fritts 1994; Mech et al. 1995; Thiel et al. 1998). While such behavior is not unique to the species, it is unique to Wolves living in the continental United States (McNay 2002; Mech and Boitani 2003). Observations of Wolves displaying increased tolerance towards humans are of value insofar as it affects management of Wolf recovery. This paper reports on the success of Wolves attempting to colonize areas of higher human densities than previously reported in the continental United States.

Study Area and Methods

Wisconsin's Central Forest Region (CFR) encompasses 7767 km^2 of deciduous forest (*Acer saccharum, Tilia americana, Quercus alba, Q. borealis, Q. velutina*), coniferous swamps (*Picea mariana, Larix laricina),* aspen stands (*Populus tremuloides, P. grandidentata*), pine barrens (*Pinus banksiana, P. resinosa, P. strobus*), sphagnum bogs, and marshes (Curtis 1959; Finley 1976*). A 12 141-hectare swamp, the largest in Wisconsin, lies within the CFR (Martin 1965). The CFR includes portions of Eau Claire, Chippewa, Clark, Jackson, Wood, Monroe, Juneau, Adams, and Marquette counties. The majority of the CFR consists of private industrial, county, state and federal forestland. Major economic industries include logging and cranberry agriculture as well as dairy operations (WDNR 2003*). Road density within the CFR is 1.23 km/km^2 (U. S. Census Bureau 2000*; WDNR 2003*).

Wolves were captured on or near rendezvous sites, located by howling and track surveys, using offset,

modified #14 Newhouse traps during summers 2002 and 2003, following guidelines established by Animal Care and Use committees within the Wisconsin Department of Natural Resources and University of Wisconsin-Stevens Point. With the exception of setting traps, researchers minimized time spent in pack rendezvous sites to avoid Wolf-human interactions with study animals. Wolves were sedated with a 5:1 mL mixture of ketamine hydrochloride and xylazine and were weighed, sexed, and examined to assess general condition (Wydeven et al. 1995).

Radio collars were placed on adults. Pups received ear tag transmitters developed for a Wolf pup mortality study (Advanced Telemetry Systems, Isanti, Minnesota) programmed to transmit from 0700 – 1900. Pups and adults were located from the ground using a receiver with either a 5-element hand held Yagi antenna or a 9-element vehicle mounted antenna once daily from time of capture to 15 January each study season. All Wolves were located from fixed-wing aircraft 1-2 times/week.

Human activity observed near pack homesites was documented. Additionally, we interviewed people and collected reports from people who encountered study pack Wolves to assess the relative level of tolerant behavior of study packs towards humans.

Aerial locations of 10 dispersing Wolves were plotted in Universal Transverse Mercator (UTM) coordinates utilizing ArcView 3.X (ESRI, Inc., Redlands, California). Township (human) and residential (structural) densities for each county in which Wolf locations were plotted were queried (U. S. Census Bureau 2005*). Measurements obtained included township densities and residential densities in the county for (1) natal territories from which Wolves dispersed, (2) locations while Wolves were dispersing, and (3) after dispersers settled and either became territorial or became breeders.

Results

We monitored 17 Wolves from three study packs in 2002 and nine Wolves in five study packs in 2003. Seven Wolves and three packs were new in 2003. In three of the six study packs we were able to detail repeated interactions with humans.

Suk Cerney pack: Three male pups, one female pup, a yearling female, and an adult male Wolf were radioed near their den site between 3-6 July 2002 on Necedah National Wildlife Refuge (NNWR) in Juneau County (44°04.957'N, 90°10.399'W). The den site was located approximately 350 m from an observation bunker and several rearing pens used as part of a Whooping Crane (*Grus americana*) reintroduction program located on the NNWR. Between July and October employees and volunteers of the crane project, NNWR staff, along with visiting news media and guests, visited the cranes at least twice per day. Crane staff and Wolf researchers routinely observed pups before and during

FIGURE 1. Capture site of Wolf 409 in central Wisconsin on 10 August 2002 and death site in eastcentral Indiana. June 2003.

our study period. One pup watched Wolf researchers from the den, located in oak savannah dominated by Hill's oak (*Quercus ellipsoidalis*) for approximately 10 minutes as traps were set on 3 July 2002, approximately 10.5 m away. Adult Wolves were rarely seen. However, radio signals confirmed they were often in the immediate vicinity. The 4 radioed pups stayed in the area despite daily human activity, until their deaths between July 15 and 5 September 2002 (Heilhecker 2003*).

Bear Bluff pack: Six Wolves were captured in and adjacent to cornfields on private land in Jackson County between 20 July and 3 August 2002 (44°15.355'N, 90°20.582'W). Two male pups and two female pups, a yearling female, and a yearling male were radio-tagged. A partially planted, sandy soil cornfield with stunted corn stalks < 0.9 m tall, used as a daily rendezvous site from July to early November in 2002 and 2003, was approximately 175 m from the maintenance building used by employees of the cranberry farm at least twice a week. Distance from the rendezvous site to the maintenance building and cranberry beds were approximately 450 m and 1300 m, respectively. White-tailed Deer (*Odocoileus virginianus*), the Wolves' primary prey in the region, were abundant and cause $35000/year damage to local commercial cranberry beds (K. Rice, Flying Dollar Cranberry Company, personal communication). Deer flies (*Chrysops* sp.) and mosquitoes (Culicidae) were generally less abundant in the corn-

fields compared to the surrounding forested land. In both years, and for years prior to our study, employees of the cranberry company regularly observed Wolves. Once during our study they witnessed a Wolf in their parking lot sniffing vehicle tires. The property manager also reported his dog interacting with Wolves in what looked like play behavior.

Noch Hanai pack: Wolf 429, a yearling female, was radio-collared on 3 June 2002. In summer 2002, she was observed multiple times acting indifferently to vehicles along State Highway 54 on the northern border of her natal pack territory (44°20.15'N, 90°35.51'W). In the autumn she dispersed and created a new pack that occupied a 102-km^2 territory centered along the same state highway. The pack's den site was discovered approximately 230 m from State Highway 54 in a Red Pine (*Pinus resinosa*) plantation with no understory. Vehicles passing on the state highway were visible from the den. The wolves' rendezvous sites, as determined by matted grass, trails, human garbage with teeth marks, and deer legs, were on embankments along the shoulder of this moderately traveled state highway, adjacent side roads, and recently logged forests spanning a distance of 7.7 km by 60 m along the state highway.

In summer 2003, over 60 citizen phone calls and e-mails reported a radio-collared Wolf with pups walking, playing, and lying in the middle of the state highway. Initially four pups and a radio-collared adult were observed. On 19 July 2003, a dead male pup was collected from the shoulder of the highway. The necropsy revealed injuries consistent with a vehicle collision.

None of the Wolves appeared to be afraid of vehicles. On 20 July 2003, a citizen reported watching three pups and a collared female in the middle of the state highway. They moved off to the shoulder of the road to let vehicles pass and then returned to the middle of the road. E. Heilhecker and W. Hall, Jr., observed Wolf 429 looking both directions before stepping onto the highway. Pups were observed sitting on the side of the road chewing on deer legs as vehicles passed. Pups once walked next to Heilhecker and Hall's vehicle parked on the shoulder of the road. In all instances the pups appeared oblivious to the presence of vehicles. It was later learned that the Wolves had been fed by loggers working in this area during the late spring/early summer.

On 13 January 2004, WDNR received a report of an uncollared Wolf on State Highway 54 jumping into the bed of a truck containing deer hides and carcasses after its occupant had stopped to take pictures of the Wolf (M. Windsor and T. Babros, WDNR, personal communication). On 29 March 2004, an uncollared Wolf was observed walking back and forth across State Highway 54 stopping traffic. At one point the Wolf picked up a yellow plastic oil container, crossed the road, and lay down within 3 m of a vehicle. Several vehicles slowed down to watch the Wolf. While no one exited their vehicles, people rolled down their windows and continued to talk within hearing range of the Wolf. The Wolf did not appear to be affected by the commotion. On 27 April 2004, the radio-collared female, Wolf 429, was humanely dispatched along Hwy 54 because she was unable to ambulate on her hind legs. A preliminary necropsy was inconclusive, but her paralysis was not caused by a vehicle collision. This Wolf did have a healed injury to the pelvic girdle that was caused by blunt trauma suggestive of an earlier collision with a vehicle (A. Dassow, University of Wisconsin, Madison, personal communication).

Dispersal: We compared aerial locations for 10 Wolves, as yearlings and adults, dispersing between 1998 and 2004. Seven Wolves (W002, W269, W309, W338, W341, W426, W429) established new territories; five of which (W309, W338, W341, W426, W429) were known to have successfully bred. Three Wolves (W337, W427, W480) continued to disperse until their deaths and never set up known territories. Township densities ($\bar{\chi}$ = 9.02 humans/km^2, SE = 4.015) and residential densities ($\bar{\chi}$ = 5.59 housing units/km^2, SE = 2.12) in natal pack territories were significantly lower ($P < 0.01$) than township densities ($\bar{\chi}$ = 43.98 humans/km^2, SE = 7.37) and residential densities ($\bar{\chi}$ = 23.12 housing units/km^2, SE = 3.49) in dispersal and post-dispersal territories (U. S. Census Bureau 2005*).

A male pup, W409, dispersed to eastern Indiana in less than 156 days. The pup was last monitored on 15 January 2003 and found dead on 20 June 2003. If the pup dispersed in a straight line, it would have passed through relatively densely settled areas of northern Illinois and the greater metropolitan Chicago area to reach eastern Indiana (40°06.4'N, 85°04.3'W) (Figure 1). The human density of Jackson County, its birthplace, was 7.8 people/km^2. The least populated counties along the Wisconsin/Illinois state border had 22.9 people/km^2 (Green County, Wisconsin) and 14.5 people/km^2 (Jo Daviess County, Illinois). The human density in Randolph County, Indiana, where the Wolf was found shot was 22.84 people/km^2 (U. S. Census Bureau 2005*). This was the first documented Wolf in Indiana since their extirpation in 1908 (Mumford and Whitaker 1982), and the southern-most movement of a radio-collared Wisconsin Wolf to date (A. Wydeven, WDNR, personal communication).

Discussion

Wolves' reactions to humans are a reflection of their experiences with people and the relative tolerance of humans to Wolves (McNay 2002; Fritts et al. 2003). By the mid-1900s Wolves were largely restricted to wilderness areas in North America due to intense human persecution (Young 1944; Mech 1995). With legal protection from the Endangered Species Act of 1973, a gradual increase in acceptance of Wolves (Fritts et al. 2003), and an expanding population, Wolves have inevitably come in closer contact with humans (Mech 1995; Thiel et al. 1998; Mech and

Boitani 2003). By the 1990s an increasing number of Wolves began dispersing into and colonizing more settled regions and agricultural areas in the northern United States (Licht and Fritts 1994; Mech 1995; Mech and Boitani 2003). Thiel et al. (1998) and Merrill and Mech (2000) reported tolerance of humans close to den and rendezvous sites in Minnesota and Wisconsin.

As Wolves colonize more fragmented habitat dominated by humans they will come into more frequent contact with humans, as our findings demonstrate. Dispersing Wolves from the numerous packs presently inhabiting the forest-farmland zones in Wisconsin and Minnesota are capable of penetrating great distances into landscapes highly dominated by humans (Licht and Fritts 1994; Merrill and Mech 2000; Fritts et al. 2003; Mech and Boitani 2003).

The male Wolf pup, 409, provides an example of this progression of tolerance to humans, a behavior that can be expected to be exhibited by Wolves in succeeding generations. Although movements of ≥ 670 km from their homesites have been well documented in Wolves (Van Camp and Gluckie 1979; Ballard et al. 1983; Fritts 1983; Ream et al. 1991; Licht and Fritts 1994; Merrill and Mech 2000; Mech and Boitani 2003), this is the first documentation of a wild North American Wolf moving through areas of such high human densities. While Wolf 409 was not known to have any contact with nor was known to have been conditioned to humans as a pup, it was subjected to increasing levels of human activity as it dispersed south and east of Lake Michigan. Interestingly, Wolf 429, the founder of what became the human-habituated Noch Hanai pack, came from the very same pack in which Wolf pup 409 was born.

We observed two forms of habituation of Wolves in our study: (1) pups that became accustomed to the presence of humans through repeated, benign association, and (2) association of humans with a food reward. In the two cases where litters were raised in close proximity to human activity and were frequently seen, the pups fled at the close presence or approach of a human(s). These Wolves created no known threats to public safety or caused any damage to personal property. Wolves displaying avoidance or fear behavior during direct encounters with humans are considered to be showing "normal" behavior (Smith and Stahler 2003*).

In the remaining case in our study, pups received food awards from humans. Wolves are not known to attack people during their first human encounter but require repeated exposure to humans before attacking (McNay 2002; Smith and Stahler 2003*). A prerequisite for aggressive Wolf behavior towards humans is habituation, with food being the most influential factor (McNay 2002; Smith and Stahler 2003*). Our human-habituated Wolves' whose bold behavior rapidly evolved into a public nuisance issue.

We expect more Wolf-human encounters and human-habituated Wolves due to the recovering Wolf population in the Great Lakes area. Wisconsin's Wolf population has increased from 83 Wolves in 1995 to 425 Wolves in 2005 (Wydeven and Wiedenhoeft 2005*). The growing Wolf population and increased number of Wolf sightings have raised safety concerns from the general public. A continuous educational program that focuses on how human actions affect Wolf behavior may minimize the establishing of human-habituated Wolves. Periodic news releases and public education programs at the federal and state forests, posters at road side kiosks emphasizing the reasons why feeding of Wolves is improper, writing stipulation in public contracts on public land prohibiting feeding of Wolves especially in areas where Wolf habituation is occurring, or fining individuals who feed Wolves may be useful approaches. When habituation occurs, attempts should be made to deter Wolves displaying bold behavior with aversion techniques such as rubber bullets and cracker shells before Wolf aggression develops. If aversion conditioning is unsuccessful, for public safety reasons, aggressively bold Wolves should be humanely euthanized.

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Influence of Gender and Den Type on Home Range Shape for Striped Skunks, *Mephitis mephitis*, in Saskatchewan

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We investigated gender differences in shape of home ranges for Striped Skunks, *Mephitis mephitis*, in southcentral Saskatchewan, Canada, during 1993-1994. Data collected on free-ranging Striped Skunks indicated that shape of female home ranges was unaffected by den type (building versus burrow) and was similar to shape of male home ranges. Moreover, type of maternity den did not influence the position of the den within the home range (inside or outside of core area). We conclude that the distribution of Striped Skunks in summer, and the distribution of their foraging activity, are not affected by the availability of anthropogenic den structures.

Key Words: Striped Skunk, *Mephitis mephitis*, home range, denning site, spatial distribution, Canadian prairies.

Fragmentation of habitats affects not only how animals are distributed in the landscape, but also their use of space. In fragmented landscapes, suitable habitats for foraging may not occur in proximity to other critical habitats for denning, parturition, or rearing of young. Therefore, mammalian females that live in fragmented landscapes face two problems: establishing a home range that includes suitable foraging habitat and finding a site for parturition and rearing of young.

For males that do not provide parental care, obtaining food is a primary drive affecting behavior during summer. In contrast, females give birth and raise a litter during the same period, and habitat preferences for raising young may not coincide with good foraging habitats. In fragmented landscapes, the compromise between optimal foraging and optimal rearing habitats may affect the establishment of home ranges, and consequently their shape. Thus, the location of maternity dens may have several implications for the distribution of foraging activity of females.

First, den location may affect the shape of the home range or the position of the den site within the home range. For example, species that rely on a burrow and central place for refuge and storage of food may benefit from a centrally located den and circular home range (Bowers 1995). However, in fragmented landscapes, females may have to prioritize either establishment of home range (find a good foraging area first, then find a suitable place to rear young within the home range), or the establishment of maternity den (find a good den first, then find a good place to forage).

We investigated the influence of gender and den types on home range shape of Striped Skunks (*Mephitis mephitis*) in the parklands of Saskatchewan, Canada. Striped Skunks are distributed across most of Canada and the United States (Rosatte and Larivière 2003). Females give birth in mid-May, and because males provide no parental care, the progeny are dependent on the mother until mid-July, when the young disperse (Larivière and Messier 1997). In Saskatchewan, female Striped Skunks use two main types of shelter for maternity dens, either anthropogenic structures (e.g., buildings, ca. 60% of maternity dens) or underground burrows (ca. 40% of maternity dens) (Larivière and Messier 1998c). The distribution and availability of both den types differ, and thus, we hypothesized that den type could influence home range shape. For example, buildings may provide good denning structure, but their position may not be in proximity to good foraging areas, a scenario that would yield an elongated home range. In contrast, a burrow may be dug presumably closer to good foraging areas, and thus home range of females using burrows could be more circular in shape. Thus, Striped Skunks provide a good model species to test predictions of den site positioning and home range shape by animals occupying fragmented landscapes.

Study Area and Methods

We conducted this study in the Prairie Pothole Region of southcentral Saskatchewan (52°45'N, 107°08'W). Small grain (i.e., wheat, barley, oats) and oil crops (mostly canola but also flax) occupy 60% of the landscape. Numerous wetlands and stands of Trembling Aspen (*Populus tremuloides*) occur throughout the area. Topography is gently rolling, and an extensive network of roads divides the land. Areas managed for nesting waterfowl are common throughout the area, and consist mostly of dense nesting cover, a mixture of native and tame grasses seeded specifically to attract upland nesting waterfowl. General characteristics of the Prairie Pothole Region are detailed elsewhere (Greenwood et al. 1995).

From April to August, 1993-1994, Striped Skunks were captured in opaque-sided livetraps (Larivière and Messier 1999) and anesthetized using halothane and Telazol® (Larivière and Messier 1996a). All individuals were equipped with a 5-sec delay motion-sensitive radio-collar (150-152 Mhz, Telonics Inc., Mesa, Arizona, USA) to monitor activity during tracking (Larivière and Messier 1997). Skunks were released at the site of capture.

Radio-collared animals were located by an observer using hand-held receiving equipment from 18:00 to 06:00, during the period of greatest activity (Larivière and Messier 1997). Individuals were located every 15 min by direct observation, auditive location, or short-range (<50 m) triangulation (Larivière and Messier 1998b). Light amplifying, night-vision goggles (AN-PVS 5, Bill's Electronics Ltd., Mildmay, Ontario) enabled visual observations at night. Tracking effort was systematically distributed among all skunks, and no animals were tracked during two consecutive nights. Striped Skunks exhibit aposematic behavior, and defensive postures are obvious (Larivière and Messier 1996b). Locations immediately following an observer-induced defensive posture were discarded from analyses due to possible observer disturbance (Larivière and Messier 1998b).

Universal Tranverse Mercator coordinates were obtained from the exact location of the skunk following its departure from the area using a portable Global Positioning System (Ensign GPS, Trimble Navigation, Cansel Survey Equipment, Burnaby, British Columbia). To increase the precision of the coordinates, we only considered locations for which ≥3 satellites were available (D'Eon 1995).

Our radio-tracking schedule was intensive (i.e., locations every 15 min), and designed to maximize direct behavioral information instead of statistical independence within an animal's home range. Using Shoener's ratio, we estimated that statistical independence between locations occurred at intervals of 270 min. However, Striped Skunks are highly mobile, and are capable of moving >1 km in 15 min, even in dense vegetation (Larivière and Messier 1998b). Thus, we assumed that short movements reflected behavioral decisions by the skunk, not physical constraints.

We defined maternity dens as any sites for which at least two of the following criteria were satisfied: repeated use for >3 consecutive days during the parturition/rearing period (15 May - 30 June), collection of grass for preparation of nest chamber, or presence of young during the rearing period (Larivière and Messier 1998a). Because some females may relocate their progeny during the rearing period, and because we could not assess why females changed maternity dens (e.g., to reduce parasite loads, disturbance, relocation to a better foraging area, etc.), we only used data on females with a single maternity den for spatial analysis of den locations within home ranges.

Our entire study area was digitized into a Geographic Information System (SPANS GIS, PCI Geomatics, Richmond Hill, Ontario, Canada). Locations of the maternity dens were plotted for all female skunks, as well as all telemetry locations to determine home range size (Larivière and Messier 1998c) and shape. Home range shape was quantified using a shape index (McGarigal and Marks 1994) that was calculated by the following formula:

$$\text{shape index} = \text{perimeter} / (2 * \sqrt{(\text{pi} * \text{area})}).$$

Thus, a smaller shape index indicates a more circular range. We compared average shape indices for males and females with a Student t-test for unpaired samples. Spatial analyses of activity centres were performed using software package TRACKER and RANGES IV, and core areas (50% minimum convex polygon; Larivière and Messier 1998c) were considered activity centers (Samuel et al. 1985).

Results

In 1993 and 1994, we radiotracked Striped Skunks during 1858 hours, and obtained home range information for 20 females and 5 males. Of the 20 females, 11 used only 1 maternity den during the entire period.

First, we predicted that because of the fixed position of buildings in the landscapes, females using buildings as maternity dens would have home ranges less circular (larger shape index) than those using burrows. This prediction was not supported by our data: the shape index of females using buildings (mean = 1.53, SE = 0.08, $n = 6$) did not differ (one-tailed $t = 0.45$, df = 9, $P = 0.33$) from the shape index of females using burrows as maternity dens (mean = 1.48, SE = 0.07, $n = 5$).

Second, we hypothesized that if females try to minimize the travel distance to any point within their respective home ranges due to lactation constraints, then home range of females should be more circular (smaller shape index) than home ranges of males. Our prediction that home ranges of females are more circular than those of males was not supported: the average shape index for females (mean = 1.46, SE = 0.03, $n = 20$) did not differ (two-tailed $t = 0.59$, df = 23, $P = 0.56$) from the average shape index of male home ranges (mean = 1.50, SE = 0.06, $n = 5$).

Third, we hypothesized that because buildings are preferred denning sites (Larivière and Messier 1998a), some buildings may be used as maternity dens but not be located within the core area of the home range. We predicted that underground burrows should occur in the core areas more often than dens in buildings. Our data also did not support this prediction: there were no associations between den type and whether or not the den was located inside the core area ($n = 12$ females; Fisher exact test, $P = 0.52$). Overall, three underground burrows were inside versus two outside the core area, whereas six buildings were inside versus one outside the core area. In total, 75% of dens were inside core areas.

In this study, we did not detect any effect of den type (anthropogenic or not) on shape of female home ranges or position of the den. Further, the shape of Striped Skunk home ranges was similar among males and females. These findings suggest that female skunks establish home ranges irrespective of den type and with rules similar to males.

Examination of the natural history of Striped Skunks may help explain the patterns observed. First, Striped Skunks in northern environments undergo long periods of inactivity during winter, and to survive such period requires sufficient body reserves (Gunson and Bjorge 1979; Hwang et al. 2007; see also Rogers 1987). Thus, establishing a home range that includes good foraging areas may be more critical than choice of maternity den, but whether choice of maternity den influences juvenile survival remains unknown. In our study area, many buildings that were deemed suitable for occupation by skunks were not utilized (Larivière et al. 1999). As well, numerous females that used underground burrows to rear young had suitable unoccupied buildings within the boundaries of their home ranges. Thus, although buildings may be convenient denning sites, they may not be necessary or provide reproductive advantages to Striped Skunks. If juvenile mortality in skunks mostly occurs after emergence, then anthropogenic den types such as buildings may be used for other reasons such as thermoregulation, protection from the elements, or simply convenience.

During the parturition/rearing period of Striped Skunks, females make nocturnal foraging trips but return to the maternity den by morning to nurse the young (Larivière and Messier 1997). Foraging movements are highly variable (0-20 km per night; Larivière et al. 1998b) and highly opportunistic, although mostly focused on insects and small mammals (Greenwood et al. 1999) and targeted to specific habitats (Bixler and Gittleman 2000; Larivière and Messier 2000). Moreover, habitat availability around used and unused buildings in our study area was similar, suggesting that distribution of resources may not affect location of maternity dens, and conversely that choice of maternity den does not affect access to resources. Suitable den sites likely were not limiting for Striped Skunks (Larivière et al. 1999). The preference of Striped Skunks for buildings may be most obvious where buildings are abundant, but absence of buildings as maternity dens probably does not affect distribution of skunks in the landscape during summer. Hence, our study reinforces the previous suggestion that food, instead of denning structures, probably affects distribution of Striped Skunks and their foraging activity in the landscape.

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Road-kill of Mammals in Nova Scotia

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We examined road mortality of wild mammals in Nova Scotia using data from (a) five years of province-wide data on wildlife collisions involving larger mammals, and (b) 20 months of observations of smaller mammals along a 160-km route near Halifax. An average of 2079 White-tailed Deer was reported killed annually on highways during 1999 through 2003, along with 14 Moose and 33 Black Bear. Female White-tailed Deer were more likely to be road-killed than males (by a factor of 1.8), yearlings more so than older animals, and there were peaks of mortality in the late spring and late autumn. The road-kill of smaller mammals was highest in the summer and least in the winter, and the most frequent mortalities were of Raccoon (28% of observations), Porcupine (27%), Skunk (17%), Snowshoe Hare (6%), Coyote (4%), and Groundhog (3%). The standardized kill-rate (number/100 km) was highest on a 100-series highway compared to trunk highways or urban streets, but the rate standardized to vehicle density was highest on trunk highways.

Key Words: White-tailed Deer, *Odocoileus virginianus*, Moose, *Alces alces*, Black Bear, *Ursus americanus*, Raccoon, *Procyon lotor*, Porcupine, *Erethizon dorsatum*, Skunk, *Mephitus mephitis*, Snowshoe Hare, *Lepus americanus*, Coyote, *Canis latrans*, Groundhog, *Marmota monax*, road-kill, mortality, wild mammals, Nova Scotia.

Roads are a defining feature of modern transportation systems. Networks of public roads connect population centers, allowing the movement of people and goods in increasingly larger numbers of fast-moving vehicles. Because much highway infrastructure traverses wildlife habitat, an unfortunate consequence is accidental collisions that threaten the lives of both people and animals, while also causing damage to property (Romin and Bissonette 1996). In Nova Scotia, for example, 503 collisions between vehicles and large wild mammals were reported in 2003, with 68 of the incidents resulting in personal injury requiring emergency services (NSDTPW 2006*). Data relating to the economic costs of such accidents have been quantified in Maine, where they result in US$32 million/year in property damage and medical costs (MEDOT 2001*). Overall in the United States, vehicle accidents involving only White-tailed Deer (*Odocoileus virginianus*) annually result in about 200 human fatalities, 30 thousand injuries, and more than US$1 billion in property damage (Conover 1997). In Europe, collisions with ungulates result in 300 human fatalities and US$1 billion in property damage annually (Bruinderink and Hazebroek 1996). Clearly, a large socio-economic cost is associated with collisions with large animals on roads.

Roads also have important ecological impacts, including the following: (a) damage to populations of some species through mortality; (b) acting as barriers to movement or disrupting behaviour in other ways; (c) destroying and fragmenting natural habitat; (d) causing pollution by de-icing salt, metals, and pesticides; and (e) enhancing access for hunters (Bennet 1991; Evink 1999). The direct mortality of larger animals due to vehicle collisions is relatively apparent and well-quantified (Clarke et al. 1998; Cain et al. 2003; Clevenger et al. 2003; Saeki and MacDonald 2004). Road-kill may affect the conservation status of species – about 65% of the mortality of the endangered Florida Panther (*Puma concolor coryi*) is caused by vehicular collisions (Harris and Gallagher 1989). Other at-risk populations threatened by road-kill mortality include Ocelot (*Leopardus pardalis*) in the U.S. southwest (Tewes and Blanton 1998), the European Badger (*Meles meles*) in Great Britain (Clarke et al. 1998), and the endangered mainland Moose of Nova Scotia (*Alces alces americana*) (NSDNR 2008*).

Many jurisdictions have implemented mitigations to reduce the frequency of collisions between vehicles and wildlife. Often, this is limited to warning signs installed along highway sections known to have high collision rates (AMEC 2004*). In some other places, highways may have perimeter fencing or even wildlife under- and over-passes to keep animals off the roads, particularly in national parks and wilderness areas (Clevenger 1997; AMEC 2004*; NBDOT 2008*). Such mitigations help prevent animals from entering the right-of-way and are successful in reducing mortality, particularly of mammals (Foster and Humphrey 1995). Interestingly, the effectiveness of animal-crossing signs in reducing collision rates has not yet been quantified (MEDOT 2001*).

Despite the fact that collisions with vehicles are an important source of mortality of wildlife, there has been little research into the phenomenon. Putman (1997) argued that such work is necessary, because understanding the biological and ecological influences

on road-kill rates is integral to the design and implementation of effective mitigations to deal with this problem. Within this context, the great majority of research into road-kill has dealt with larger mammals. This focus is due to several socio-economic factors, including the danger to people associated with collisions with large mammals, their economic importance in hunting, and their high public profile (Cain et al. 2003; Clevenger et al. 2003). A few studies have also examined factors influencing road-kills of smaller mammals (Garland and Bradley 1984; Clevenger et al. 2003; Saeki and Macdonald 2004).

In the present study the road-kill mortality of larger- and medium-sized mammals is examined for a variety of roads in Nova Scotia. Two data sets were used: (a) province-wide incident data for larger mammals over a five-year period, and (b) data for medium-sized mammals over a 20-month period along a 160-km work-day commute. We examine biological and environmental factors possibly influencing the road-kill rates, including gender, age, and proximity to distinctive habitats.

Methods

This study was done in Nova Scotia, an eastern province with a population of about 934 thousand people and 23 thousand km of public roads (NSDTPW 2008*). Data for larger mammals were obtained from incident reports of the Nova Scotia Department of Natural Resources (NSDNR), which records road-kill of White-tailed Deer, Moose (*Alces alces*), and Black Bear (*Ursus americanus*), including the location, date, species, sex, and age of the dead animals. Although the reporting of kills is not mandatory, NSDNR estimates that 60-90% of bear and deer collisions and all involving Moose are reported to them (see Conover et al. 1997). The original NSDNR data were taken from a FoxPro database and converted to Excel spreadsheets. The original location coordinates were converted to UTM using ArcView software to allow for analysis by a geographical information system (GIS).

The number of road-kills for each species was summed monthly and annually from 1999 through 2003. The data for White-tailed Deer and Moose were also analyzed by gender and by yearling and multi-year animals. A GIS analysis was used to plot the distribution of road-kills on digital maps, and spatial relationships with road type and traffic volume were examined. In cases where the carcass was not found immediately beside a road, because the wounded animal had moved before it died, the nearest road was inferred as the place of impact. The traffic volume of highway segments was identified for reaches between successive exits and interchanges, using archived data from NSDTPW (2008*). The 100-series highways of Nova Scotia have relatively high traffic volumes and are often four lanes with controlled access, while the trunk highways are relatively low-volume, two-laned, and have free access. The annual road-kill data were standardized on a per-km and per-10^4 vehicles basis, and were compared across highway types and on the basis of adjacent habitat (categories were: mature softwood forest (>60% conifer trees), mature hardwood (>60% angiosperm trees), mature mixedwood, immature forest, agricultural, and urban land-use; a separate analysis involved surface water within 100 m.

The relationship of road-kill density was also compared with indicators of local species abundance for White-tailed Deer and Moose. For deer, density was indicated by county-level Pellet Group Inventory (PGI) data (obtained by NSDNR in the spring, after snowmelt but before green-up, along 460 random 1 km × 2 m transects throughout the province). For Moose, the abundance polygons of Snaith (2001) were used.

Data for smaller mammals were collected over a 20-month period during 1993 through 1994 along a 160-km weekday commuting route (by M. Crowell) from the rural village of Urbania to the urban Burnside Industrial Park in Dartmouth. The route included 106 km of 100-series highway (part of Highway 102), 38 km of trunk highway (Highway 215), and 16 km of urban road. Animals observed dead beside the road were identified to species, as juvenile or adult, and the location was mapped. The annual road-kill data were standardized per km of road, per km^2 of road-bed, and per 10^4 vehicles of traffic density (using archived data from NSDTPW (2008*)). The total-kill data and that for Raccoon (*Procyon lotor*), Porcupine (*Erethizon dorsatum*), and Striped Skunk (*Mephitis mephitis*) were analyzed with respect to adjacent habitat along the surveyed reaches of 100-series highway, including: (a) roadbed being lower than, raised, or level with the adjacent terrain; (b) adjacent habitat being mature softwood forest, mature hardwood, mature mixedwood, immature forest, agricultural, or urban land-use; and (c) surface water within 100 m. A coefficient of similarity was used to make pair-wise comparisons of the relative dominance of species among road-types: $S_s = 2C/(A+B)$, where C is the number of species killed on both road-types, while A and B are the numbers on particular road-types.

Observations and Discussion

White-tailed Deer

A total of 10 397 White-tailed Deer were reported killed in vehicle collisions from 1999 through 2003, or an annual average of 2 079. This mortality is equivalent to about 6% of the estimated deer population, and is a 28% increment on top of the reported hunt (on average, hunters take 20% of the Nova Scotia herd during the fall hunt; NSDNR 2007*). The road-kill rate was similar during 1999 through 2001 (average ± SD: 2 137 ± 102), but greater than during 2002 and 2003 (1 449 ± 44; $P = 0.003$ for difference between the groups of years). The smaller road-kill of 2002-2003 is likely related to a reduced deer herd during that period (NSDNR 2007*).

There was a bimodal pattern of peak mortality of multi-year individuals (of both sexes) during June-

July and October-November (Figure 1a). Other authors have reported a fall peak of deer road-kill, and have attributed this to breeding activities (Puglisi et al. 1974; Case 1978). During the rut, bucks move about in search of receptive females, and does are also relatively vagile during that period (Banfield 1974). The fall hunting season may also increase road-kill rates (Puglisi et al. 1974; Allen and McCullough 1976), although Kilgo et al. (1998) found that deer in Florida generally avoid roads and other open areas when under hunting pressure. The increase of deer road-kill in June-July could be related to such factors as increased rural traffic associated with tourists and cottagers, the availability of high-quality forage and residual de-icing salt along verges, harassment by biting flies and partial refuge from them in open areas, and increased mobility of does with fawns during this time. Puglisi et al. (1974) commented on the attractiveness of early-greening road verges to deer in the springtime. We observed a particularly large peak of road-kill in the spring of 2001 following an extremely harsh winter, during which about half of the provincial herd starved to death because of deep snow cover (NSDNR 2007*).

Adult females were 1.8-times more likely to be killed in vehicle collisions than adult males. This is likely due to the Nova Scotian deer herd being disproportionately female because of the selective removal of males by hunters (Feldhamer et al. 1986; Bruinderink and Hazebroek 1996). Yearling mortality was 11% of the total road-kill mortality, and the kill rate was similar to that of adults (when standardized by estimated population size), although there was little seasonality of the yearling mortality.

The road-kill rate was higher on two-lane secondary highways (0.38 kills/km.yr) than on four-lane 100-series highways (0.13/km.yr). Bashore et al. (1985) made a similar observation in Pennsylvania, where there were more deer road-kills along two-lane roads than along a larger interstate highway. Putman (1997) found that deer would routinely cross secondary roads within their territory, but would avoid larger interstate highways, likely because of their greater width and faster and more plentiful traffic.

The road-kill rate per 10^4 vehicles was higher on secondary ($0.092/10^4$ vehicles) than on 100-series highways ($0.012/10^4$). Overall, however, we did not find a clear relationship between road-kill rates and traffic volume at most of the tested spatial scales, suggesting that more cars do not directly relate to more accidents. Carbaugh et al. (1975) also did not find a linear relationship between traffic density and deer kills, and Armstrong (2005*) reported a slight inverse relationship. Although we did not examine the phenomenon, it is likely that high traffic rates during crepuscular hours would be particularly lethal to deer trying to cross roads (Allen and McCullough 1976).

We observed seven clusters of deer road-kills, each located near a human population centre with a high-density road network. A linear regression using average county data found a positive correlation between the estimated density of deer and that of road-kill ($R^2 = 0.71$; $P < 0.01$).

In some areas, road-kill may exert a controlling influence on local deer populations and slow their recovery from high winter mortality. There are economic implications of such effects because White-tailed Deer are the most valuable wildlife resource in North America in terms of hunting (Conover 1997; DuWors et al. 1999*). Romin and Bissonette (1996) estimated that the inclusive value of deer in North America is about $2 200 per animal (Canadian dollars adjusted for inflation to 2005).

Moose

Seventy Moose were reported killed in vehicle collisions from 1999 through 2003 (average = 14/yr). About two-thirds of the mortality involved the relatively abundant population on the highlands of Cape Breton, which is derived from 18 released individuals (*Alces alces andersoni*) imported from Alberta in the late 1940s (Pulsifier and Nette 1997). The annual road-kill mortality is equivalent to about 0.23% of the Cape Breton population, and 3.7% of the reported harvest by hunters (in 2003; this does not include the Mi'kmaq harvest, which is estimated to be similar to or exceeding the licenced hunter harvest). However, the native mainland population of Moose (*Alces alces americana*) is much less abundant, likely fewer than a thousand individuals, and since 2003 it has been listed as endangered under the *Nova Scotia Endangered Species Act*. The annual road-kill mortality of mainland Moose is equivalent to about 0.5% of the population (there is no legal hunting of this population).

Moose road-kills occurred in all months except April, with a peak of male mortality in October, and of females during June-July (Figure 1b). The autumn peak of male mortality occurs during the rut, when they are competing and moving about in search of receptive females (Banfield 1974). Males also become more aggressive during the rut and may be less averse to roads and traffic (Joyce and Mahoney 2001). The female peak of road-kill in early summer is related to the high volume of tourism-related traffic that occurs then on Cape Breton highways, particularly on the Cabot Trail.

Similar numbers of males and females were killed on the mainland (10 vs. 12), but 1.6-times more females were killed on Cape Breton roads. The latter observation is related to the female-skewed sex distribution of Moose on Cape Breton (the gender ratio of kills by hunters is about three males per two females). Yearling mortality was 11% of the total, but their kill rate was similar to that of adults (when standardized by their estimated population size). There was no obvious seasonality of the yearling mortality.

Of the road-kills on Cape Breton, 85% occurred along eastern sections of the Cabot Trail, where traffic volumes are relatively high. The highest kill rate (0.4/10 km. yr) occurred along a stretch from French

River Bridge to Wreck Cove along the Cabot Trail, within Cape Breton Highlands National Park. On mainland Nova Scotia, the highest road-kill rate was on Highway 104 on the upland Cobequid Pass Toll highway, where 38% of the mainland kills occurred (0.2/10 km.yr). These high-kill areas coincide with regions of Nova Scotia that have the highest density of Moose (Snaith 2001).

Black Bear

One hundred and sixty-four Black Bears were reported killed in vehicle collisions from 1999 through 2003 (average = 33/yr). The annual mortality is equivalent to about 0.5% of the estimated population of Black Bears in Nova Scotia, and 7.2% of the reported harvest by hunters (in 2003). The lowest kill-rate was in 1999 (10 individuals) and the highest in 2003 (57). An unusually large number of 27 bears were road-killed in June 2003, compared to the 1999-2002 June average of 5. This may have been due to an increasing bear population, or the springtime of 2003 being unusually cool and wet, so that animals emerging from hibernation had trouble finding adequate natural food and were attracted to areas near human settlement.

There was a bimodal pattern of road-kill mortality, with peaks in May-June and in October-November (Figure 1c). The first peak is likely due to activity associated with the breeding season, when males wander in search of females (Klenney 1987). The early summer is also when sub-adult animals, at about 15 months of age, leave their mothers to find their own territory (Matson 1967). The fall peak of mortality is likely related to activity associated with pre-hibernation feeding and movement to denning sites (Matson 1967; Davis and Browne 1996). No road-kills were recorded from mid-November to early April, when bears are in hibernation. It was not possible to factor the influence of age or sex on bear road-kill, as these data were not consistently recorded.

Bear road-kills occurred throughout the province, except in southeastern Cape Breton, where the species does not have an established population (Macmichael 2007). The 100-series highways had a higher linear mortality rate (1.58 kills/100 km.yr) than secondary highways (0.032/100 km.yr). According to traffic density, however, the 100-series and secondary highways had similar mortality rates (both 0.02 kills/10^6 vehicles.year). Relative to their total estimated population size in Nova Scotia, Black Bear road-kill rates are lower than those of White-tailed Deer. This may be due to bears being relatively wary of humans and roads, except for habituated animals (Herrero 1985). In addition, deer tend to be relatively abundant in areas of Nova Scotia with high populations of people, especially in agricultural and coastal regions.

Other Mammals

Three hundred and ninety-two smaller mammals of sixteen species were recorded as road-kill on a 160-km study route during a 20-month survey (Figure 1d). The most frequent mortalities were of Raccoon (28% of kills), Porcupine (27%), and Striped Skunk (18%). These are relatively abundant in the study area, often occurring near roads and other habitat edges, and are at inherent risk because they are relatively deliberate in their movements and have a body too large to pass beneath most moving vehicles without impact (Garland and Bradley 1984; Rolley and Lehmen 1992; Clevenger et al. 2003). All species recorded as road-kill are indigenous to the study area, except for Coyote, *Canis latrans*, domestic cat, *Felis domesticus*, and domestic dog, *Canis familarus* (Banfield 1974; Davis and Browne 1996). Additionally, a Red-necked Wallaby (*Macropus rufogriseus*) that had been a 6-month escapee from a wildlife park was found by one of us as road-kill in the Annapolis Valley of Nova Scotia.

Discoveries of small-mammal road-kills (rodents and shrews) were uncommon, but this is likely due to the difficulty of detecting these animals when scanning from a moving vehicle, plus the likelihood that they are quickly scavenged. In addition, small mammals are reluctant to cross multi-lane highways (Clevenger et al. 2003). An innate reluctance to cross open spaces may also explain why Snowshoe Hare, *Lepus americanus* (the most abundant medium-sized mammal in the study area), was killed less frequently than Raccoon, Porcupine, or Striped Skunk, and why their kill rate was higher on the two-lane Highway 215 than on the four-lane Highway 102. Clevenger et al. (2003) also found that Snowshoe Hare was more likely to be killed on narrow roads than on wider ones in Banff National Park, Alberta.

The road-kill rate, when standardized by distance surveyed, was highest on the four-lane Highway 102 (6.0 kills/km) than on the two-lane Highway 215 (4.0/km) or city streets (1.3/km). However, when standardized to traffic density, Highway 215 had a greater rate of mortality (6.3 kills/10^4 vehicles) than Highway 102 (1.9/10^4 vehicles). The kill rate per 10^4 vehicles approached zero on urban streets because of the large traffic volumes, lower vehicle speeds, and likely a relatively small abundance of wild mammals. The lower rate on Highway 102 is likely due to its much greater width and larger volume of faster-moving vehicles, which likely discouraged animals from crossing. Clevenger et al. (2003) also found that relatively wide and high-traffic roads discouraged small- and medium-sized mammals from crossing in Alberta, as did Clarke et al. (1998) for badgers in England.

Similar numbers of species were observed killed on the four-lane Highway 102 (n=12) and on the secondary Highway 215 (n=11), and both exceeded urban streets (only Red Squirrel, *Tamiasciurus hudsonicus*, were observed road-killed in the urban area studied). The most frequent mortalities on the secondary Highway 215 were Raccoon (19% of the total), Striped Skunk (18%), Red Squirrel (16%), Snowshoe Hare

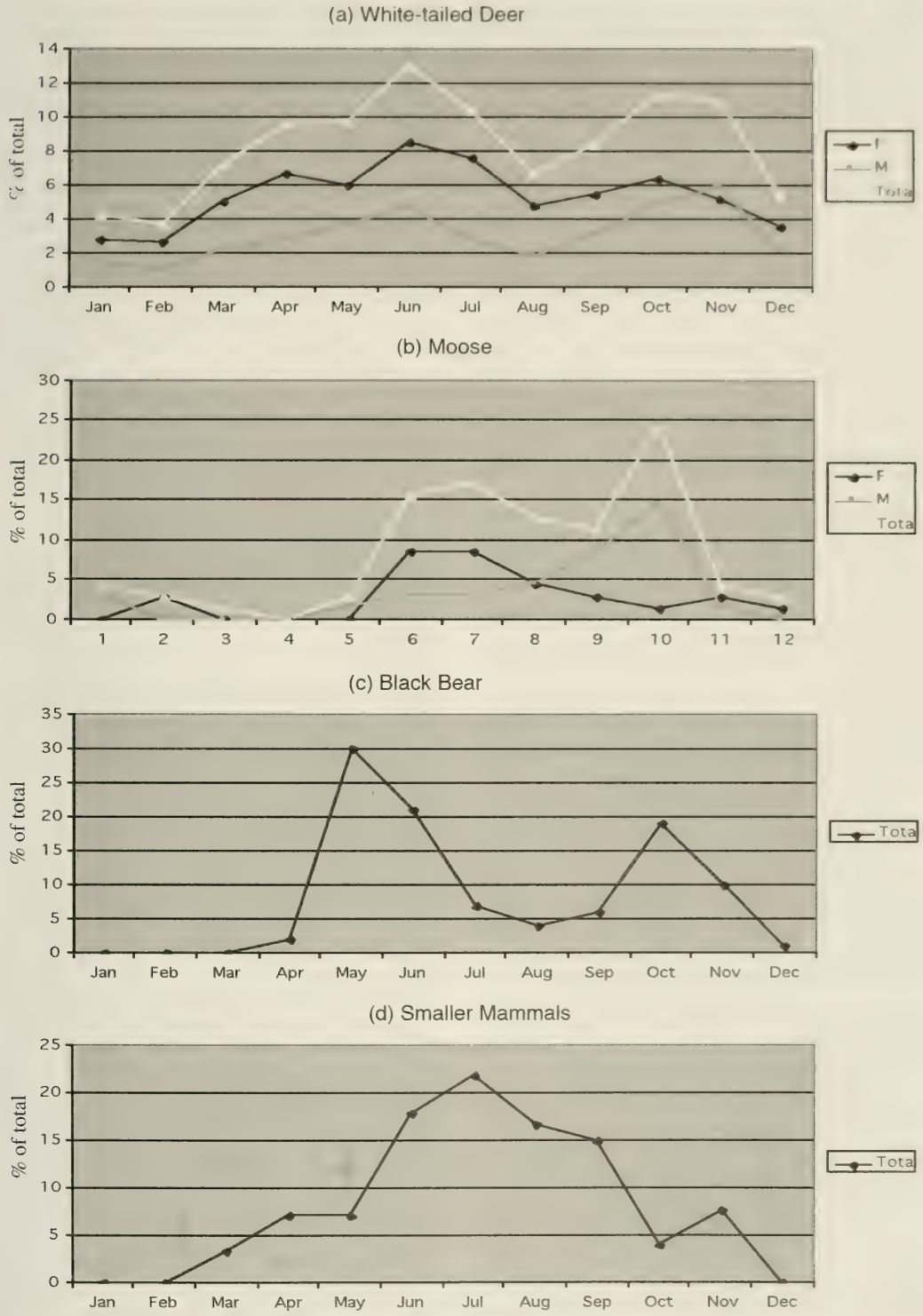

FIGURE 1. Average monthly road-kill mortality of large mammals from 1999 through 2003: (a) White-tailed Deer (n = 10 397); (b) Moose (n = 70); (c) Black Bear (n = 164); (d) smaller mammals (n = 392). Sum of genders may not add to totals, because the sex of some animals was not identified.

(14%), and Porcupine (11%). The most frequent on the four-lane Highway 102 were Porcupine (31%), Raccoon (30%), and Striped Skunk (18%). The species spectrum of mortality of Highways 102 and 215 had a similarity coefficient of 0.78, but their similarity with urban streets was very low – only 0.00 and 0.08, respectively.

The greatest rate of road-kill occurred in the summer months of June (35 mortalities), July (34) and August (22) (Figure 1d). Smaller numbers were recorded in the winter months of November through February, when animals are hibernating or generally less active. The road-kill of Raccoons was highest in May and June, when adult males search widely for females with which to mate (Banfield 1974). In addition, 43% of the Raccoon mortality in May and June was yearlings, which disperse during that time. The mortality of Striped Skunks was highest in September, when juveniles disperse from their natal home range. The mortality of Porcupines was relatively even throughout the spring, summer, and fall.

Partial-deviance tests indicate that roadside topography and habitat were significant predictors of Raccoon road-kill. The likelihood of a Raccoon road-kill was much greater at level roadside topography ($\chi^2 = 11.3$, df = 3, $P < 0.001$) and along segments of highway bisecting mature forest ($\chi^2 = 9.4$, df = 3, $P < 0.05$). Proximity to water did not have a significant effect ($\chi^2 = 0.50$, df = 1, $P > 0.05$). The likelihood of Raccoon road-kill at different roadside topographies was assessed using log-likelihood ratios, and was much greater at level crossings (T-value = 3.1; $P < 0.05$) and along segments bordering mature forest (T-value = 5.9; $P < 0.0025$). For Porcupines, topography ($\chi^2 = 29.4$, df = 4, $P < 0.005$) and proximity to water ($\chi^2 = 5.9$, df = 1, $P < 0.025$) were significant predictors of road-kill. Log-likelihood ratios indicate that road-kill was most frequent at level roadside topography (T-value 4.1; $P < 0.025$) and adjacent to mature softwood forest (T-value 4.0; $P < 0.025$). For Striped Skunks, topography ($\chi^2 = 27.4$, df = 2, $P < 0.005$) was the only significant predictor of road-kill, and the log-likelihood of mortality was much higher at level roadside topography (T-value = 4.1; $P < 0.025$).

Overall, no road-kills of any species were observed at sites where the roadbed was raised (higher than the adjacent terrain), and the likelihood of road-kill was higher on roads bisecting mature forest (mixed, softwood, or hardwood) than adjacent to immature forest, agricultural fields, or urban habitat (T-value 3.8; $P < 0.05$). Proximity to water did not have an overall significant predictive effect.

The results suggest that far fewer road-kills occurred on raised than on level or buried roadbeds. Raised roadbeds could serve as a visual barrier to habitat on the other side, and the banked incline may act as a physical deterrent to crossing. Clevenger et al. (2003) made similar observations for smaller-animal road-kills in Banff National Park, where raised roadbeds had a lower risk of mortality than other topographies.

Another factor potentially affecting road-kill rates is the presence of vegetated center medians on divided highways, such as the grassy ones occurring on Highway 102 in the present study. Bellis and Graves (1971) suggest that these habitats function as temporary refuge areas for animals attempting to cross major highways.

Our study does not allow for an assessment of the impact of road-kill mortality on the local abundances of smaller mammals, as population estimates are not available. If our data were extrapolated to the total length of 100-series (3×10^3 km) and secondary (4×10^3 km) highways in Nova Scotia, the estimated annual mortality within this size range would be 20×10^3 mammals. It can be concluded that the numbers of animals killed on Nova Scotian highways is large, and that this is a significant anthropogenic stressor. Our field data for smaller mammals were collected in 1993-1994, and since then traffic volumes on Nova Scotian roads have increased by about 24% since then (NSDTPW 2008*), so it is likely that road-kill rates have also increased. Moreover, some new roads are being built and the 100-series highways are being expanded, which may also be increasing the rates of road-kill.

Mitigation

Clearly, large numbers of mammals are being killed on Nova Scotian roads, and the further creation and upgrading of highways and increasing traffic may worsen this situation. Moreover, there are important socio-economic consequences of collisions with wildlife. These include injuries to people involved in the collisions, the associated medical costs and time off work, damages to property, and decreases in the populations of animals available to be hunted or trapped. For example, during our study period of 1999 through 2003, White-tailed Deer were involved in 204 vehicle collisions in which people suffered injuries requiring hospitalization, and seven incidents involved a human fatality (NSDTPW 2006*). In fact, White-tailed Deer cause more collision-related property damage and human mortality than any other wild animal in North America (Conover 1997). According to Putman (1996), an average collision with a deer costs about $3 400 in vehicle damage (Canadian dollars, adjusted for inflation to 2005). Using this cost estimate, deer collisions in Nova Scotia during our study period resulted in about $6.8 million in annual property damage, not including costs associated with health care and emergency services.

Fortunately, there are ways to reduce road-kill along highways (Woods 1990*; Clevenger et al. 2001; USDOT 2002*; AMEC 2004*). Some mitigations are intended to change the behavior of animals in ways that make them less likely to enter the right-of-way. For example, fencing is used to prevent animals from

Table 1. Road-kill of smaller mammals over a 20-month study period.

Species	Highway 101		Highway 215		Urban	Total	
	n	%	*n*	%	*n*	*n*	%
Raccoon (*Procyon lotor*)	97	29.9	11	19.3	0	108	27.5
Porcupine (*Erethizon dorsatum*)	101	31.2	6	10.5	0	107	27.3
Striped Skunk (*Mephitis mephitis*)	60	18.5	10	17.5	0	70	17.9
Snowshoe Hare (*Lepus americanus*)	14	4.3	8	14.0	0	22	5.5
Domestic Cat (*Felis domesticus*)	17	5.2	4	7.0	0	21	5.4
Coyote (*Canis latrans*)	13	4.0	0	0.0	0	13	3.3
Groundhog (*Marmota monax*)	10	3.1	2	3.5	0	12	3.1
Red Squirrel (*Tamiasciurus hudsonicus*)	0	0.0	9	15.8	3	9	2.3
Domestic Dog (*Canis familiaris*)	4	1.2	2	3.5	0	6	1.5
Red Fox (*Vulpes vulpes*)	4	1.2	0	0.0	0	4	1.0
Eastern Chipmunk (*Tamias striatus*)	0	0.0	3	5.3	0	3	0.8
Beaver (*Castor canadensis*)	1	0.3	0	0.0	0	1	0.3
Mink (*Mustela vison*)	1	0.3	0	0.0	0	1	0.3
Muskrat (*Ondatra zibethicus*)	1	0.3	0	0.0	0	1	0.3
Red-backed Vole (*Clethrionomys gapperi*)	0	0.0	1	1.8	0	1	0.3
Woodland Jumping Mouse (*Zapus hudsonicus*)	0	0.0	1	1.8	0	1	0.3
Unknown mammal	1	0.3	0	0.0	0	1	0.3
Total Species = 16	324		57		3	392	

crossing major roadways in at least eleven U.S. states (MEDOT 2001*), New Brunswick, and in the Canadian Rockies. In Banff National Park, for example, fencing resulted in a 96% reduction in large-mammal road-kill (Clevenger 1997). It is generally recommended that fencing be at least 2.6 m in height, including above winter snow levels (USDOT 2002*). However, fencing also has drawbacks, because it can fragment populations and may trap animals within a right-of-way that they may enter via a break or at a fence-end (Phillips 1999*). Phillips (1999*) estimated that fencing along a major highway in New Brunswick typically costs $40 000 to $80 000 (Canadian) per kilometer. At present, the only areas in Nova Scotia with wildlife fencing along road verges are on the Cabot Trail on Cape Breton Island to prevent devastating collisions with Moose in segments where there are steep drop-offs along the highway, and an area near Magazine Hill in Dartmouth that had experienced a high number of accidents with deer.

Although extremely expensive, structural crossings can be installed to allow for the movement of animals across a right-of-way. This mitigation can help prevent local and even regional populations of certain animals from becoming fragmented, with potentially deleterious consequences, while also avoiding risks to people and property from collisions. Crossing structures include underpasses, overpasses, and modified watercourse structures (a kind of underpass). However, not all animals will use structural crossings. Reed (1981) observed that Mule Deer (*Odocoileus hemionus*) were reluctant to use enclosed underpasses, and they did not acclimatize to them over a study period of 10 years. He suggested that deer were far more willing to use open "bridge" style overpasses than underpasses. A review by USDOT (2002*) also concluded that ungulates were most likely to use overpass structures. The installation of a single overpass crossing structure can cost Canadian $1.4-2.6 million, while underpasses and modified watercourse structures are generally $92 000 to $420 000 (MEDOT 2001*).

Another useful mitigation is to make drivers more aware of potential dangers and to reduce vehicular speeds (AMEC 2004*). These driver-orientated approaches include signage and educational programs. Passive warning signs (sometimes with flashing lights) of White-tailed Deer and Moose are used in many places in Nova Scotia and elsewhere to alert motorists to increased risks of collision with wildlife, generally in places where repeated collisions have occurred (AMEC 2004*). Although there are no data supporting the efficacy of signs, they likely have limited effectiveness because they rely on driver attentiveness, yet people quickly become desensitized to them (USDOT, 2002*). Passive signs are, however, relatively inexpensive to install and maintain.

Driver education related to road-kill may make motorists more aware of the potential for wildlife encounters, and therefore better prepared to avoid them. For example, a program called "Watch out for Wildlife" is delivered in the public-school system and by driver-education messaging in Florida (Evink 1999). The effectiveness of education programs in reducing road-kill is difficult to quantify, although people skilled at spotting animals and predicting their behaviour tend to be involved in fewer collisions (Joyce and Mahoney 2001).

In Nova Scotia, enhanced public awareness of wildlife-collision risks could be promoted by an increased educational program. In addition, fencing verges in stretches of all major roads known to have high kill rates of larger mammals would reduce hazards, partic-

ularly for conservation of the at-risk mainland Moose population along the Cobequid Pass of Highway 104 (which also has high rates of bear and deer road-kills). However, roadside fencing could also detrimentally fragment the habitat of the already-small populations of mainland Moose in these areas.

Of course, mitigations have significant costs, but they provide large benefits by reducing property damage and risks of injury to people and wildlife.

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Third Census of Seabird Populations of the Gaspé Peninsula, Québec, 2002

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Cotter, Richard, and Jean-François Rail. 2007. Third census of seabird populations of the Gaspé Peninsula, Québec, 2002. Canadian Field-Naturalist 121(3): 274-286.

In the tradition of the quinquennial census of seabirds in the Migratory Bird Sanctuaries along Québec's North Shore, which began in 1925, this paper presents the results of the first three seabird censuses of the Gaspé Peninsula conducted in 1979, 1989, and 2002, with an emphasis on the third census and on changes in seabird populations that occurred between the second and third censuses. In 1979 the population of seabirds was estimated at 134 163 birds, and this increased 72% to 231 186 birds in 1989. The upward trend in population continued in the 1990s but less sharply. The 2002 census recorded 279 276 birds, a 21% increase over the second census. The seabird community of the Gaspé Peninsula comprises 14 species. In each of the three censuses, three species accounted for over 75% of the total seabird population: Northern Gannet, Black-legged Kittiwake, and Common Murre. Between 1989 and 2002, Common Eider, Northern Gannet, Great Cormorant, Ring-billed Gull, Razorbill, and Black Guillemot increased in numbers, whereas Herring Gull, Black-legged Kittiwake, and Common Tern all suffered declines. Populations for Double-crested Cormorant, Great Black-backed Gull, and Common Murre all remained stable. Very small populations (<25 birds) of Leach's Storm-Petrel and Atlantic Puffin have been recorded during the censuses at only one location, Bonaventure Island. In the 2002 census there were no petrels observed, neither of adults nor of active burrows.

À l'instar des inventaires quinquennaux des oiseaux marins dans les refuges d'oiseaux migrateurs de la Côte-Nord, entrepris en 1925, cet article présente les résultats des trois premiers inventaires complets des oiseaux de mer nicheurs en Gaspésie, menés en 1979, 1989 et 2002. Une attention particulière est mise sur le statut des espèces d'après le troisième inventaire, et sur les tendances des populations entre les deux derniers inventaires. En 1979, le nombre d'oiseaux marins nicheur était évalué à 134 163 oiseaux, puis ce total a augmenté de 72% pour atteindre 231 186 oiseaux en 1989. Cette tendance à la hausse a continué dans les années 90, mais moins rapidement. En 2002 l'estimation était de 279 276 oiseaux, soit une hausse de 21 % par rapport au deuxième inventaire. La communauté d'oiseaux de mer de la Gaspésie est formée de 14 espèces nicheuses. Dans chacun des trois inventaires, trois espèces représentaient plus de 75 % de la population totale des oiseaux marins: le Fou de Bassan, la Mouette tridactyle, et le Guillemot marmette. Entre 1989 et 2002, l'Eider à duvet, le Fou de Bassan, le Grand Cormoran, le Goéland à bec cerclé, le Petit Pingouin et le Guillemot à miroir ont vu leurs nombres croître, tandis que le Goéland argenté, la Mouette tridactyle et la Sterne pierregarin subissaient des déclins. Les populations de Cormoran à aigrettes, Goéland marin et Guillemot marmette sont demeurées stables. Les petites populations (<25 oiseaux) d'Océanite cul-blanc et de Macareux moine n'ont été vues durant ces inventaires qu'à l'île Bonaventure. Cependant, aucun nid actif d'océanite ne fut localisé à cet endroit en 2002.

Key Words: Seabirds, populations, larids, alcids, Gaspé Peninsula, Bonaventure Island, Forillon National Park, Québec.

Seabird populations of the Gaspé Peninsula have long been well known due to two very popular summer tourist destinations: Forillon National Park of Canada and the town of Percé. At Percé boat tours are offered around Rocher Percé and Bonaventure Island, which together form a provincial park as well as a federal Migratory Bird Sanctuary. The most striking features of these sites are the high vertical cliffs holding large Black-legged Kittiwake colonies and the spectacular Northern Gannet colony on Bonaventure Island. (Scientific names are in Table 1.) With eight breeding seabird species numbering more than 100 000 pairs in 2002, Bonaventure Island is undoubtedly the most important seabird colony in the area; nevertheless, the smaller mainland cliffs, together with a few islands and sand bars distributed around the peninsula, are also home to numerous colonies of cormorants, gulls, guillemots and Razorbills.

Chapdelaine and Brousseau (1992) published the first account the distribution and abundance of all seabird species breeding along the entire Gaspé Peninsula in eastern Québec. They presented the results of the first systematic censuses of seabirds for the region–in 1979 and 10 years later in 1989–as well as changes in populations and distribution for each species. After an interval of 13 years, in 2002 the Canadian Wildlife Service conducted a third seabird census. The objective of this paper is to present the results of all three censuses, but with an emphasis on describing the changes in seabird populations and distribution that occurred between 1989 and 2002. This paper therefore complements and updates Chapdelaine and Brousseau (1992) who discussed the changes that occurred between 1979 and 1989.

Methods

On the Gaspé Peninsula, seabird species (Table 1) were censused at 59 breeding sites (Table 2, Figure 1) during June and early July in 1979, 1989, and 2002 by the Canadian Wildlife Service-Québec Region. There

TABLE 1. Species names and summary of census methods used for each species in the 1979, 1989, and 2002 seabird censuses of the Gaspé Peninsula.

English name	Scientific name	Methodology
Common Eider	*Somateria mollissima*	systematic counts of all nests, except for Îlot Mahy nord where flushed females were counted
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	systematic counts of active burrows
Northern Gannet	*Morus bassanus*	population analysis from aerial photography
Double-crested Cormorant	*Phalacrocorax auritus*	nests counted from a boat, except for the Upper Plateau of Rocher Percé where nests were counted from a look out point using a spotting scope
Great Cormorant	*Phalacrocorax carbo*	nests counted from a boat
Ring-billed Gull	*Larus delawarensis*	systematic counts of all nests
Herring Gull	*Larus argentatus*	systematic counts of nests; ratio calculated where nested with Great Black-backed Gulls; counts of incubating adults on cliffs made from a boat
Great Black-backed Gull	*Larus marinus*	systematic counts of nests (sometimes from boat); ratio calculated where nested with Herring Gull
Black-legged Kittiwake	*Rissa tridactyla*	Bonaventure Island, Cap d'Espoir, Forillon Peninsula: counts derived from photographs (taken from boat); elsewhere nests were counted from a boat
Common Tern	*Sterna hirundo*	systematic counts of all nests
Common Murre	*Uria aalge*	counts of birds at colonies on cliffs; used a conversion factor of 0.76 pair/bird observed
Razorbill	*Alca torda*	counts of birds at colonies on cliffs
Black Guillemot	*Cepphus grylle*	counts of birds at colonies on cliffs and on the water; used Cairns (1979) conversion factor to estimate the number of breeding pairs
Atlantic Puffin	*Fratercula arctica*	counts of adult birds

were three exceptions with respect to the year of the census, and these were: Black Guillemots at Cloridorme to Marsoui were counted in 1980 instead of in 1979, Common Eiders at Pointe de Sandy Beach were counted in 2003 instead of in 2002, and Northern Gannets at Bonaventure Island were counted in 2004 instead of in 2002. The census techniques employed varied among species and colonies but were consistent for each colony among the three censuses (i.e., 1979, 1989, and 2002). A detailed explanation of the techniques used in 1979 and 1989 can be found in Chapdelaine and Brousseau (1992); with few exceptions the same methods were used in 2002. A brief description of the techniques used in 2002 for each species is presented in Table 1. Certain species, such as Black Guillemots and Herring and Great Black-backed gulls, nest in colonies as well as solitary pairs or in very small groups. As such, for these species the distribution and colony size data may pertain to a section of shoreline rather than a discrete colony. At colonies where a species was believed to have been present but there are no population estimate available, a "+" is indicated in the corresponding table. To examine changes in population sizes between the three censuses, that is from 1979 to 1989 and from 1989 to 2002, the compound annual growth rate (CAGR) was calculated for each species using the formula: CAGR = $(((N(t)-N(0))/N(0)+1)^{1/t})-1$ where $N(t)$ = population size at time t, $N(0)$ = population size at time 0 and t = number of years between two censuses.

Results

During the surveys in 1979, 1989, and 2002, a total of 14 species of seabirds was recorded at 59 breeding sites (colonies and/or shoreline sectors) around the Gaspé Peninsula (Tables 1, 2). Twelve species were observed in all three censuses, with the remaining two absent in one of the census years (Tables 3-8). In 2002, 13 species were observed, with only the Leach's Storm-Petrel not recorded. In terms of total abundance (number of individuals) and breeding sites, the censuses recorded 134 163 birds at 44 sites in 1979, 231 186 birds at 58 sites in 1989, and 279 276 birds at 57 sites in 2002 (Table 8). In each of the three survey years, three species accounted for over 75% of the total seabird population—Northern Gannet, Black-legged Kittiwake, and Common Murre. Individual species accounts are as follows:

Common Eider: In 2001, the total population of breeding eiders (subspecies *dresseri*) in the St. Lawrence Estuary and Gulf was estimated at 42 000 pairs (The Joint Working Group on the Management of the Common Eider 2004). The 2002 seabird census of the Gaspé Peninsula recorded only 235 pairs of this eider, which represents less than 1% of the total population in Québec. Nevertheless, the population is steadily increasing, from 41 pairs in 1979 to 128 pairs in 1989 to 235 pairs in 2002 (Table 8). In 2002 this seabird bred at Îlot Mahy nord, Île Plate, and Pointe de Sandy Beach (Table 6). A few pairs are also believed to nest each year at the foot of the cliff on the Forillon Peninsula.

TABLE 2. Number, name, and centroïd coordinates of sites on the Gaspé Peninsula surveyed for nesting seabirds in 1979, 1989, and 2002. (Colony numbers correspond to locations in Figure 1.)

Miguasha to Îlot Mahy Sud sector		Îlot Mahy Nord to Forillon sector	
Colony	Coordinates[1]	Colony	Coordinates[1]
1. Miguasha to Saint-Omer	48°04'N, 66°18'W	29. Îlot Mahy nord	48°15'N, 64°45'W
2. Saint-Omer	48°07'N, 66°15'W	30. Banc de la baie du Grand Pabos	48°20'N, 64°42'W
3. Banc de Carleton	48°06'N, 66°08'W	31. Barachois de Chandler	48°21'N, 64°41'W
4. Île au Pique-Nique	48°06'N, 66°07'W	32. Île Dupuis	48°21'N, 64°40'W
5. Île Taylor	48°09'N, 65°51'W	33. Chandler to Grande-Rivière	48°21'N, 64°39'W
6. New Richmond to Bonaventure	48°09'N, 65°50'W	34. Barachois de Pabos	48°23'N, 64°35'W
7. Pointe Howatson	48°08'N, 65°49'W	35. Grande-Rivière to Cap d'Espoir	48°24'N, 64°29'W
8. Caps Noirs	48°07'N, 65°48'W	36. Grande-Rivière	48°25'N, 64°26'W
9. Caplan	48°06'N, 65°39'W	37. Sainte-Thérèse-de-Gaspé	48°25'N, 64°25'W
10. Ruisseau Leblanc	48°05'N, 65°37'W	38. Cap d'Espoir to Percé	48°25'N, 64°19'W
11. Marais de Saint-Siméon	48°04'N, 65°33'W	39. Cap d'Espoir	48°26'N, 64°19'W
12. Bonaventure to Paspébiac	48°02'N, 65°29'W	40. Cap Malin	48°27'N, 64°19'W
13. Îlots de la rivière Bonaventure	48°03'N, 65°28'W	41. Weygand	48°29'N, 64°17'W
14. Paspébiac Ouest	48°02'N, 65°17'W	42. Cap Blanc	48°30'N, 64°13'W
15. Marais de Paspébiac	48°02'N, 65°15'W	43. Bonaventure Island	48°30'N, 64°10'W
16. Paspébiac to Shigawake	48°01'N, 65°15'W	44. Rocher Percé	48°32'N, 64°12'W
17. Pointe aux Corbeaux	48°02'N, 65°13'W	45. Percé to Cannes de Roches	48°32'N, 64°12'W
18. Pointe Huntington	48°03'N, 65°11'W	46. Les Trois Soeurs	48°32'N, 64°13'W
19. Pointe à Ritchie	48°03'N, 65°09'W	47. Coin-du-Banc to Pte St-Pierre	48°34'N, 64°18'W
20. Saint-Godefroi	48°05'N, 65°06'W	48. Barachois de Malbaie	48°36'N, 64°18'W
21. Shigawake to Chandler	48°06'N, 65°04'W	49. Île Plate	48°38'N, 64°09'W
22. Shigawake	48°06'N, 65°03'W	50. Pointe St-Pierre to Douglastown	48°37'N, 64°10'W
23. Colline de Port-Daniel	48°08'N, 64°59'W	51. La Grande Anse	48°41'N, 64°14'W
24. La Vieille (Pointe Pillar)	48°11'N, 64°56'W	52. Bois-Brûlé	48°46'N, 64°22'W
25. Gascons-Ouest	48°11'N, 64°53'W	53. Douglastown to Sandy Beach	48°46'N, 64°22'W
26. Pointe Reddish	48°11'N, 64°52'W	54. Cap Haldimand	48°48'N, 64°23'W
27. Anse à Pierre Loiselle	48°12'N, 64°49'W	55. Pointe de Sandy Beach	48°50'N, 64°24'W
28. Îlot Mahy sud	48°15'N, 64°45'W	56. Pointe Jacques Cartier (Gaspé)	48°51'N, 64°29'W
		57. Forillon Peninsula	48°47'N, 64°12'W
		58. Cloridorme to Marsoui	49°11'N, 64°50'W
		59. Marsoui to Baie des Capucins	49°13'N, 66°04'W

[1] For shoreline sections, the coordinates of the starting locations are given.

Leach's Storm-Petrel: On the Gaspé Peninsula, this petrel has only ever been known to nest at two locations, Forillon Peninsula and Bonaventure Island. By the 1930s, the Forillon colony no longer existed (Ball 1938), leaving only the Bonaventure Island colony. This colony was probably never large–in the 1979 and 1989 censuses only 10 and 21 pairs were counted, respectively. Unfortunately, no petrels (nor active burrows) were observed in the 2002 census (Table 7). In fact, this species' breeding status in Québec is currently uncertain. Historically, it nested at several locations along the North Shore of the Gulf of St. Lawrence and on the Magdalen Islands. However, the only active colony found in the 1998-1999 census of North Shore Migratory Bird Sanctuaries (Corossol Island with 718 active burrows, Rail and Chapdelaine 2004) was deserted in the 2005 census (Rail and Cotter 2007), and no active burrow has been recorded on the Magdalen Islands in the last 20 years, although observations in 2007 of adults in the Île Brion Ecological Reserve during a survey for this species suggest a small colony still exists there (CWS, unpublished data). In some cases, including Bonaventure Island, the presence of Red Foxes (*Vulpes vulpes*) might be responsible of the abandonment of the colony.

Northern Gannet: On the Gaspé Peninsula, this species nests only on Bonaventure Island. During the last census the Northern Gannet was the most abundant of all seabirds with an estimated 53 635 pairs (Table 8). Since 1979 this gannet colony has grown at a fairly consistent rate; the compound annual growth rate (CAGR) was 2.8% between 1979 and 1989 and 5.5% between 1989 and 2004 (Table 8). This colony was also censused in 1999 and was estimated at 36 936 pairs; the CAGR for 1999 to 2004 was 7.7%. In 1999 and 2004 the colony showed no sign of density-dependant effects, and because breeding success estimates obtained in 1999 and 2004 were high and stable (CWS, unpublished data), we think that the colony should continue to increase in the next few years.

Double-crested Cormorant: After a doubling in population size between 1979 and 1989, the size of this cormorant's population on the Gaspé Peninsula did not change substantially between 1989 and 2002 (CAGR of only 0.4%), reaching 4 889 pairs in 2002 (Table 8). A stabilization in populations between the mid-1980s

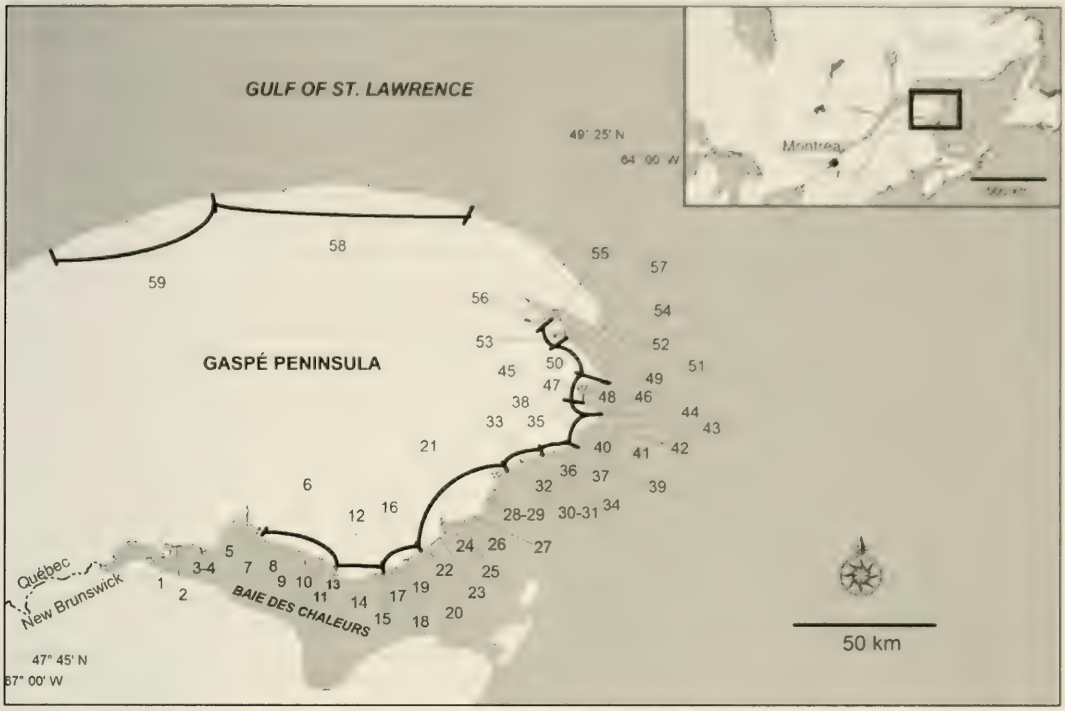

FIGURE 1. Location of colonies and shoreline sectors on the Gaspé Peninsula surveyed for breeding seabirds in 2002. See Table 2 for location listings and coordinates.

and the early 2000s has also been recorded in Nova Scotia (Boyne and Beukens 2004) and New Brunswick (Boyne and Hudson 2002). In Québec, the population on the Magdalen Islands also remained fairly stable between 1990 and 2002 (CWS, unpublished data), as did the overall population in breeding colonies within the Migratory Bird Sanctuaries along the St. Lawrence North Shore between 1993 and 2005 (Rail and Cotter 2007). Interestingly, the increase in the size of the Gaspé population between 1979 and 1989 was accompanied with an additional nine new colonies in 1989, bringing to a total of 29 active colonies that year. In 2002, however, there was a contraction in the number of sites where it nested, as it was recorded at only 25 sites (Tables 4, 6, 7). Of the nine new colonies in 1989, three were not active in 2002. Additionally, six colonies that were active in both 1979 and 1989 harboured no cormorants in 2002. The loss of these nine colonies was offset by five new colonies, including one comprising 393 pairs in the New Richmond-Bonaventure region and, interestingly, a small colony on Bonaventure Island. As Chapdelaine and Brousseau (1992) stated, the majority of Double-crested Cormorant colonies on the Gaspé Peninsula are found on sea-cliffs that in some areas are unstable and subject to erosion. Thus it is not surprising that between censuses with an interval of ≥10 years there are colonies that become inactive and new ones are created.

Great Cormorant: World-wide this species has the largest breeding distribution of all cormorant species, but only a small fraction of its population nests in North America (Hatch et al. 2000). In Québec there are approximately 20 small colonies (total population <1500 pairs) (CWS, unpublished data), with historically only one colony on the Gaspé Peninsula at Rocher Percé. In 1979 this colony had 16 nesting pairs, and in the 1989 census this number had doubled to 35 pairs. This upward trend continued in the 1990s as the total Gaspé population reached 96 pairs in 2002 (Table 7). In that census, the Rocher Percé colony had changed little in size since 1989, but a new and fairly large colony of 50 pairs was found at Cap d'Espoir (Table 7). Small numbers (1-3 pairs) were also observed at four other sites in 2002 (Tables 4, 6), which along with the new colony at Cap d'Espoir may indicate the population is expanding not only in size but also in its distribution. Rail and Chapdelaine (2004) also reported on the recent appearance of small Great Cormorant colonies in North Shore Migratory Bird Sanctuaries, although the most recent survey of these sanctuaries, in 2005, recorded only 48 Great Cormorants, a sharp decrease from the previous survey in 1998-1999 when 342 adults were counted (Rail and Cotter 2007).

Ring-billed Gull: This gull, whose first breeding record in the Maritime Provinces was in 1965 (Lock 1988), is also a newcomer to the Gaspé Peninsula. It

was absent during the 1979 census, and in 1989 only 21 pairs were counted at two sites, Barachois de Chandler and Pointe de Sandy Beach (Table 5). In the 2002 census, however, there was only one colony and it was not at either of those two sites. Instead it was at Saint-Omer, and the colony was surprisingly quite large with 1663 pairs (Table 3). There were more Ring-bills at this site than the traditional species that nest there, that is Herring and Great Black-backed gulls and Common Terns. With numbers of Ring-billed Gulls still rising in the Maritimes (Boyne and Hudson 2002; Boyne et al. 2006) and apparently also on the North Shore (Roberge 2004), it is not surprising to observe the same trend around the Gaspé Peninsula.

Herring Gull: Among all seabirds on the Gaspé Peninsula, the Herring Gull is the only species whose population declined in size between 1979 and 1989 and again between 1989 and 2002 (Table 8). From 1979 to 1989 its CAGR was -1.8%, and this rate of decline doubled to -3.5% between 1989 and 2002. Between 1979 and 2002, the total population declined from 9796 to 5134 pairs. This decline is attributable to colonies decreasing in size as opposed to a reduction in the number of breeding sites (24 in 1979 vs 29 in 2002; Table 8). In 2002, 22 of the 29 colonies had fewer gulls than in 1989. There were, however, four colonies/sectors that increased in size by more than 50% between 1989 and 2002: Saint-Omer, Île Taylor, Marais de Paspébiac, and the New Richmond to Bonaventure sector (Tables 3, 5). These four areas along with Îlot Mahy sud and Pointe de Sandy Beach comprised 64% of the total Herring Gull population on the Gaspé Peninsula in 2002. The decline in colony size is probably not a result of competition, such as for nest or foraging areas, with other larids. Among the 22 sites where the population declined between 1989 and 2002, there were only two–Îlot Mahy sud and Île Plate–that had a sizable increase in the population of another seabird, and at both sites it was of Great Black-backed Gulls (three other sites had smaller increases in their Great Black-backed Gull populations; Tables 3, 5). Along coastal New England, however, the more aggressive Great Black-backed Gulls have displaced Herring Gulls from certain good breeding sites, and Rome and Ellis (2004) found evidence there that Great Black-backed Gulls may suppress foraging by Herring Gulls. Elsewhere in Canada, populations of Herring Gulls have also declined in Newfoundland (Robertson et al. 2004), New Brunswick (Boyne and Hudson 2002), Nova Scotia (Boyne and Beukens 2004), and Prince Edward Island (Boyne and McKnight 2005). Chapdelaine and Rail (1997) showed that there was a positive relationship between Herring Gull populations in the North Shore sanctuaries and cod fishery activities in the Gulf of St. Lawrence, the latter providing substantial amounts of fish offal and discards to breeding gulls. After a thriving period that lasted up to the end of the 1980s, the cod fishery collapsed, a situation which probably triggered the decline of the Herring Gull populations on the North Shore (-70% between 1988 and 1993; Chapdelaine 1995) and around the Gaspé Peninsula as well (-37% between 1989 and 2002). We think that the disappearance of this abundant anthropogenic food source brought Herring Gull populations back to a more "natural" level, which will stabilize in the future, as has been observed in North Shore sanctuaries since the early 1990s (Rail and Cotter 2007).

Great Black-backed Gull: This large gull often nests in mixed colonies with its more abundant relative, the Herring Gull. Unlike that species, however, Great Black-backs increased dramatically in numbers on the Gaspé Peninsula between 1979 and 1989, with a CAGR of 23.7%. After reaching a population of 1 337 pairs in 1989, the population in 2002 was relatively unchanged with 1 322 pairs. The large increase from 1979 to 1989 was due in part to colonies increasing in size but also to a doubling in the number of colonies (Table 8). Comparing 2002 with 1989, there were a few changes in colony locations. In 2002 this gull did not nest at Barachois de Chandler but colonized the Banc de la baie du Grand Pabos in the adjacent bay, less than 1 km away. It also deserted the cliffs from Paspébiac to Shigawake, but became established between New Richmond and Bonaventure. Elsewhere, in each of the neighbouring Maritime Provinces Great Black-backed Gull numbers declined between the late 1980s and early 2000s (Boyne and Beukens 2004; Boyne and Hudson 2002; Boyne and McKnight 2005). In the Migratory Bird Sanctuaries (excluding Gros Mécatina and Saint-Augustin) along the St. Lawrence North Shore, however, the population has been relatively stable, with 1 883 individuals counted in 1988 and 1 835 individuals counted in 2005 (Rail and Chapdelaine 2004; Rail and Cotter 2007).

Black-legged Kittiwake: This small larid was the most abundant seabird species in both 1979 and 1989 (Table 8). The size of the kittiwake population on the Gaspé Peninsula doubled in size in the 1980s, from 21 827 pairs in 1979 to 43 423 pairs in 1989. This species' distribution and abundance between 1974 and 1985 have been described in detail for the entire Gulf of St. Lawrence by Chapdelaine and Brousseau (1989). In the 1990s, the population stopped growing, and in 2002 there were 13% fewer pairs (37 649) than there were in 1989. Recent downward trends (i.e., negative annual growth rates) have been observed in other regions of eastern Canada: Magdalen Islands (Québec), -1.0%/year, 1989-2000; Anticosti Island (Québec), -2.3%/year, 1985-2004; North Shore Migratory Bird Sanctuaries (Québec), -8.0%, 1988 to 1998-1999 but followed by a stabilization with a rate of 0.64%, 1998-1999 to 2005; Gull Island (Newfoundland), -2.2%, 1971-2001; Great Island (Newfoundland), -9.9%, 1994-2003; and Baccalieu Island (Newfoundland), -3.6%, 1984-2003 (CWS, unpublished data; Rail and Cotter 2007; Robertson et al. 2004; G. Robertson, personal communication). In each of the

TABLE 3. Distribution, species composition, and changes in population size of larids breeding between Miguasha and Îlot Mahy sud on the Gaspé Peninsula in 1979, 1989, and 2002. (Population sizes are given in pairs.)

Colony	Ring-billed Gull			Herring Gull			Great Black-backed Gull			Black-legged Kittiwake			Common Tern		
	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002
1. Miguasha to Saint-Omer				1											
2. Saint-Omer			1 663	209	495	703	2	62	104					133	333
3. Banc de Carleton				40	136	12	2	27	1				390	841	
4. Île au Pique-Nique				175	29	29	17	62	102						
5. Île Taylor					202	351		27	124					318	
6. New Richmond to Bonaventure				527	506	902	3		13			83			
7. Pointe Howatson															
8. Caps Noirs															
9. Caplan											22				
10. Ruisseau Leblanc												572			
11. Marais de Saint-Siméon					2									36	15
12. Bonaventure to Paspébiac				487	482	144	1	3	2			127			
13. Îlots de la rivière Bonaventure					12										
14. Paspébiac Ouest															
15. Marais de Paspébiac					239	390		21	33						20
16. Paspébiac to Shigawake				589	797	172	1	20							
17. Pointe aux Corbeaux															
18. Pointe Huntington															
19. Pointe à Ritchie											56	4			
20. Saint-Godefroi											405	288			
21. Shigawake to Chandler				233	453	110	4	1	4			3			
22. Shigawake															
23. Colline de Port-Daniel											15				
24. La Vieille (Pointe Pillar)										13	324	7			
25. Gascons-Ouest												121			
26. Pointe Reddish											202	159			
27. Anse à Pierre Loiselle											18	263			
28. Îlot Mahy sud					142	36		94	264						
Total	0	0	1 663	2 261	3 495	2 849	30	317	647	13	1 042	1 627	390	1 328	368

TABLE 4. Distribution, species composition, and changes in population size of cormorants and alcids breeding between Miguasha and Îlot Mahy sud on the Gaspé Peninsula in 1979, 1989, and 2002. (Population sizes are given in pairs except for Razorbill which is individual birds.)

Colony	Double-crested Cormorant			Great Cormorant			Common Murre			Razorbill			Black Guillemot		
	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002
1. Miguasha to Saint-Omer															
2. Saint-Omer															
3. Banc de Carleton															
4. Île au Pique-Nique															
5. Île Taylor															
6. New Richmond to Bonaventure			393									1	31	68	175
7. Pointe Howatson	5	11													
8. Caps Noirs	363	415													
9. Caplan	134	62	75												
10. Ruisseau Leblanc		152	116												
11. Marais de Saint-Siméon															
12. Bonaventure to Paspébiac													91	62	194
13. Îlots de la rivière Bonaventure															
14. Paspébiac Ouest	224	622	198												
15. Marais de Paspébiac															
16. Paspébiac to Shigawake			98									10	13	54	318
17. Pointe aux Corbeaux	52	106													
18. Pointe Huntington	34	24													
19. Pointe à Ritchie	88	281	128												
20. Saint-Godefroi	177	246	250			3									
21. Shigawake to Chandler			8									17	159	230	236
22. Shigawake		17							2						
23. Colline de Port-Daniel	25	7													
24. La Vieille (Pointe Pillar)	116	173	119												
25. Gascons-Ouest	27	18	27												
26. Pointe Reddish		3	10												
27. Anse à Pierre Loiselle															
28. Îlot Mahy sud	58	353	673												
Total	1 303	2 490	2 095	0	0	3	0	0	2	0	0	28	294	414	923

TABLE 5. Distribution, species composition, and changes in population size of larids breeding between Îlot Mahy nord and Baie des Capucins on the Gaspé Peninsula in 1979, 1989, and 2002. (Population sizes are given in pairs.)

Colony	Ring-billed Gull			Herring Gull			Great Black-backed Gull			Black-legged Kittiwake			Common Tern		
	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002	79	89	02
29. Îlot Mahy nord				3 360	836	525	54	358	26						
30. Banc de la baie du Grand Pabos						102			8						
31. Barachois de Chandler		15		586	108	5		3						217	
32. Île Dupuis				480	20	38		8	9						
33. Chandler to Grande-Rivière				4		101			8						
34. Barachois de Pabos				70											
35. Grande-Rivière to Cap d'Espoir				251	365	202		15	2						
36. Grande-Rivière											301	12			
37. Sainte-Thérèse-de-Gaspé										45	135				
38. Cap d'Espoir to Percé				386	624	250	3	6	4						
40. Cap Malin															
41. Weygand															
42. Cap Blanc											45				
45. Percé to Cannes de Roches				37	91	2		5	1						
46. Les Trois Soeurs						33				420	1 774	413			
47. Coin-du-Banc to Pte St-Pierre				3											
48. Barachois de Malbaie				66	210	38		28	45						
49. Île Plate				755	525	125	2	166	237						
50. Pointe St-Pierre to Douglastown				239	352	79		6	6						
51. La Grande Anse															
52. Bois-Brûlé															
53. Douglastown to Sandy Beach				42	87	7									
54. Cap Haldimand															
55. Pointe de Sandy Beach		6		+	488	429	+	241	151				69	862	20
56. Pointe Jacques-Cartier (Gaspé)						1									
58. Cloridorme to Marsoui					21										
59. Marsoui to Baie des Capucins															
Total	0	21	0	6 279	3 727	1 937	59	836	497	465	2 255	425	69	1 079	20

TABLE 6. Distribution, species composition, and changes in population size of eiders, cormorants, and alcids breeding between Îlot Mahy nord and Baie des Capucins on the Gaspé Peninsula in 1979, 1989, and 2002. (Population sizes are given in pairs except for Razorbill which is individual birds.)

Colony	Common Eider			Double-crested Cormorant			Great Cormorant			Razorbill			Black Guillemot		
	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002
29. Îlot Mahy nord	1	23	70		233	736									
30. Banc de la baie du Grand Pabos															
31. Barachois de Chandler															
32. Île Dupuis				161	60	513									
33. Chandler to Grande-Rivière													27		27
34. Barachois de Pabos															
35. Grande-Rivière to Cap d'Espoir													87	79	193
36. Grande-Rivière															
37. Sainte-Thérèse-de-Gaspé					145	68			2						
38. Cap d'Espoir to Percé													72	96	215
40. Cap Malin					2										
41. Weygand					10	14									
42. Cap Blanc					15						2				
45. Percé to Cannes de Roches													119	107	81
46. Les Trois Soeurs											6	42			547
47. Coin-du-Banc to Pte St-Pierre													41	230	26
48. Barachois de Malbaie															
49. Île Plate	35	102	150	35	142	227									
50. Pointe St-Pierre to Douglastown						41			1				228	495	387
51. La Grande Anse				23	75										
52. Bois-Brûlé				12	210	121									
53. Douglastown to Sandy Beach													7	59	28
54. Cap Haldimand				198	183	46									
55. Pointe de Sandy Beach		3	15[1]												
56. Pointe Jacques-Cartier (Gaspé)					158	312									
58. Cloridorme to Marsoui													511[2]	474	871
59. Marsoui to Baie des Capucins													+	107	341
Total	36	128	235	429	1 233	2 078	0	0	3	0	8	42	1 092	1 647	2 716

[1] Censused in 2003 (Serge Brodeur, personal communication).
[2] Censused in 1980.

TABLE 7. Principal seabird colonies on the Gaspé Peninsula and changes in population sizes, 1979 to 1989 to 2002. (Population sizes are given in pairs except for Razorbill and Atlantic Puffin which are individual birds.)

Species	39. Cap d'Espoir			43. Bonaventure Island			44. Rocher Percé			57. Forillon Peninsula			TOTAL		
	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002	1979	1989	2002
Common Eider				10	21					5	+	+	5	+	+
Leach's Storm-Petrel													10	21	0
Northern Gannet				18 245	24 125	53 635[1]							18 245	24 125	53 635
Double-crested Cormorant	29	98	48			10	467	474	244	238	371	414	734	943	716
Great Cormorant			50			2	16	35	38				16	35	90
Herring Gull	64	167	13	+	137	57	599	250	164	593	429	114	1 256	983	348
Great Black-backed Gull	1	12	2	11	37	10	50	123	157	9	12	9	71	184	178
Black-legged Kittiwake[2]															
- visual	1 879	4 492	2 069	15 647		11 127	16	1 387	1 094	3 807		7 476	21 349	40 126	35 597
- photograph			2 542		23 650	18 550					10 597	13 411			
Common Murre			3	11 866	27 857	28 239			21			399	11 866	27 857	28 662
Razorbill		2	23	307	552	1 278	3	27	126	14	45	91	324	626	1 518
Black Guillemot	33	23	64	75	101	167	64	72	190	475	794	1 107	647	990	1 528
Atlantic Puffin				2	+	5							2	+	5

[1] Bonaventure Island censused in 2004 instead of in 2002.
[2] Annual estimates used in calculating the Total estimate are underlined.

three Gaspé Peninsula censuses, five colonies comprised ≥95% of the total kittiwake population: Cap d'Espoir, Bonaventure Island, Les Trois Soeurs, Rocher Percé, and Forillon Peninsula (Tables 5, 7). Comparing colony sizes in 2002 with 1979, the former three colonies had changed by less than ±35%, whereas the latter two had increased substantially in size, in particular Rocher Percé, which increased from 16 pairs in 1979 to 1 094 pairs in 2002 (Table 7). In each of the three censuses, the Bonaventure Island colony harboured the most kittiwakes, with an estimated 18 550 pairs nesting in 2002. After the 1989 census, at which time there were 23 650 pairs at this colony, Chapdelaine and Brousseau (1992) postulated that the Bonaventure Island colony may have reached its peak due to a lack of available nesting habitat.

Common Tern: Of all species censused in 1979, 1989, and 2002, the Common Tern had the greatest change in CAGR over the 1989 to 2002 period as compared with 1979 to 1989 (Table 8). In that first interval, the population increased at an annual rate of 18.0%, from 459 pairs in 1979 to 2 407 in 1989. From 1989 to 2002, however, the tern population declined at a CAGR of -13.1%. The 2002 population was estimated at only 388 pairs, which is fewer birds than there were in 1979 (Table 8); only one other species, the Leach's Storm-Petrel, had a smaller population in 2002 than in 1979. Terns have never nested at a large number of sites on the Gaspé Peninsula. In 1979 the Common Tern nested only at Banc de Carleton and Pointe de Sandy Beach, and both of these colonies had increased considerably in size by 1989 and were the largest of all tern colonies, with each containing over 800 pairs (Tables 3, 5). In addition to these two colonies, there were four new colonies in 1989, and among these six colonies four had 200 or more nesting pairs. In 2002, however, there were only four colonies, of which three consisted of 20 or fewer pairs. During this census there were no terns at Banc de Carleton and only 20 pairs at Pointe de Sandy Beach. The only bright spot for this species was the colony at Saint-Omer, which was a new colony in 1989. In that year this colony consisted of 133 pairs, which increased to 333 pairs in 2002. Elsewhere in Québec, tern numbers on the Magdalen Islands were quite stable between 1990 and 2000 at around 2 600 pairs (CWS, unpublished data), and in the Mingan Archipelago National Park Reserve, on the North Shore of the Gulf of St. Lawrence, numbers have been increasing in the last 20 years, with more than four thousand pairs in 1999 (Roberge 2004). In neighbouring New Brunswick, the number of Common Terns along the Gulf of St. Lawrence coast has been relatively stable, with a small decline between 1983 (15 500 pairs) and 2000 (12 618 pairs) and then a small increase in 2005 (13 283 pairs) (Boyne et al. 2006). The situation on Prince Edward Island over this same period has been more drastic, as the island's population fell from

TABLE 8. Total population sizes of seabirds breeding on the Gaspé Peninsula in 1979, 1989, and 2002 and the compound annual growth rates (CAGR) between each census year. (Population sizes are given in pairs except for Razorbill and Atlantic Puffin which are individual birds.)

Species	1979 Population	1979 Number of colonies	1989 Population	1989 Number of colonies	CAGR 1979-1989	2002 Population	2002 Number of colonies	CAGR 1989-2002
Common Eider	41	3	128	3	12.1%	235	3	4.8%
Leach's Storm-Petrel	10	1	21	1	7.7%	0	0	
Northern Gannet	18 245	1	24 125	1	2.8%	53 635[1]	1	5.5%
Double-crested Cormorant	2 466	20	4 666	29	6.6%	4 889	25	0.4%
Great Cormorant	16	1	35	1	8.1%	96	6	8.1%
Ring-billed Gull	0	0	21	2		1 663	1	40.0%
Herring Gull	9 796	24	8 205	28	-1.8%	5 134	29	-3.5%
Great Black-backed Gull	160	14	1 337	23	23.7%	1 322	24	-0.1%
Black-legged Kittiwake	21 827	7	43 423	15	7.1%	37 649	16	-1.1%
Common Tern	459	2	2 407	6	18.0%	388	4	-13.1%
Common Murre	11 866	1	27 857	1	8.9%	28 664	5	0.2%
Razorbill	324	3	634	6	6.9%	1 588	8	7.3%
Black Guillemot	2 033	16	3 051	16	4.1%	5 167	18	4.1%
Atlantic Puffin	2	1	+	1		5	1	
Total (individuals)	134 163		231 186		5.6%	279 276		1.5%

[1] Censused in 2004.

approximately 3 000 pairs in 1984 to 738 pairs in 2004 (Boyne and McKnight 2005).

Common Murre: Of the three most abundant seabirds, the Common Murre showed the strongest growth in population between 1979 and 1989 with a CAGR of 8.9% (Table 8). The population more than doubled in size between those two censuses, from 11 866 pairs in 1979 to 27 857 in 1989. From 1989 until the next census in 2002, however, the population increased only marginally to 28 664 pairs (CAGR of 0.2%) (Table 8). Across the Gulf of St. Lawrence, in the Migratory Bird Sanctuaries of the North Shore, between 1977 and 1988 annual growth was approximately 9% (Chapdelaine and Brousseau 1991) but between 1988 and 1998-1999 the population stabilized and the annual growth was <1.5% (Rail and Chapdelaine 2004). This was followed, however, by a 50% decline in the total murre population in the sanctuaries between 1998-1999 and 2005 (CAGR of -11.8%) (Rail and Cotter 2007). In both 1979 and 1989 there was only one murre colony on the Gaspé Peninsula, and that was on Bonaventure Island. In 2002 this colony was about the same size as it was in 1989 with 28 239 pairs (Table 7). There were, however, three new small colonies in 2002: Cap d'Espoir, Rocher Percé, and Forillon Peninsula (Table 7). Of these three new sites, Forillon contained the largest number of murres with an estimated 399 pairs.

Razorbill: Whereas the population of Common Murres increased considerably in size between 1979 and 1989 but then stablized, the population of this alcid doubled in size between each census. With 324 individuals in 1979, the Razorbill population increased to 634 in 1989 (CAGR of 6.9%) and then to 1 588 in 2002 (CAGR of 7.3 %) (Table 8). In all three censuses Razorbills were recorded at Bonaventure Island, Rocher Percé, and Forillon (Table 7). In 1989 and 2002 they also nested at Les Trois Soeurs and Cap d'Espoir (Tables 6, 7), and in 2002 three new small colonies were discovered, for a total of eight colonies that year. The Bonaventure Island colony accounts for ≥80% of the total Razorbill population on the Gaspé Peninsula. This percentage, however, has been declining, from 97% in 1979 to 87% in 1989 to 80% in 2002, despite the fact that this colony grew from only 307 birds in 1979 to 1 278 in 2002. As observed with many other species, the population of Razorbills along the St. Lawrence North Shore has shown a similar trend with the Gaspé population. In Migratory Bird Sanctuaries surveyed in that region at 5-6 year intervals, this alcid had annual growth of 8.6% and 7.3% for 1993 to 1998-1999 and 1998-1999 to 2005, respectively (Rail and Cotter 2007). In the St. Lawrence Estuary, the size and number of colonies have also been growing over the past 20 years (CWS, unpublished data).

Black Guillemot: The population of Black Guillemots on the Gaspé Peninsula has exhibited a consistent upward trend since 1979, with a CAGR of 4.1% for both 1979 to 1989 and 1989 to 2002 periods (Table 8). With such a rate of increase, this population has more than doubled in size between 1979 (2 033 pairs) and 2002 (5 167 pairs). The number of shoreline sectors where this alcid has been recorded during each of the three censuses has changed very little. In both 1979 and 1989 it was recorded at 16 sites, and this increased to 18 in 2002 (Table 8). For the first time, in 2002 a good-sized colony of guillemots was observed at Les Trois Soeurs. With 547 pairs, only Forillon Peninsula and the long stretch of coastline from Cloridorme to Marsoui harboured more guillemots. This little seabird is also doing well in the Migratory Bird Sanctuaries of the St. Lawrence North Shore, where the population has increased from 411 birds in 1993 to 924 birds in 2005 (Rail and Cotter 2007).

Atlantic Puffin: With the possible exception of the Leach's Storm-Petrel, this species is the least common of all seabirds on the Gaspé Peninsula. It is known to nest only on Bonaventure Island, where "a few pairs breed on the cliffs amid thousands of Northern Gannets and Common Murres" (Chapdelaine 1996). Breeding sites, probably hidden at the deep end of cliff ledges, cannot be counted, but small numbers (≤5 birds) of puffins were seen during each of the three censuses (Table 7).

Discussion

The first systematic seabird survey of the Gaspé Peninsula in 1979 recorded a population of approximately 134 000 birds. Over the next 10 years this population increased by 72% to just over 231 000 birds. During that decade, large increases in seabird numbers were also observed along the North Shore of the Gulf of St. Lawrence. Migratory Bird Sanctuaries in that region are censused every 5-6 years, and seabird populations within those sanctuaries increased by 65% between 1977 and 1982 (Chapdelaine and Brousseau 1984) and by 46% between 1982 and 1988 (Chapdelaine and Brousseau 1991). For both the Gaspé and the North Shore, the large increases in seabird populations in the 1980s may be attributed to increases in forage fish such as sandlance (*Ammodytes* spp.) and Capelin (*Mallotus villosus*) in the waters of the Estuary and Gulf of St. Lawrence, and the increase in the supply of forage fish may have occurred because of the decline in Cod (*Gadus morhua*) and other predator fish species due to overfishing (Chapdelaine and Brousseau 1991, 1992). Also, the decrease in some fishery activities may have resulted in reduced mortality of birds getting entangled in fishing gear. Finally, the consumption of seabirds and their eggs, often illegal, is probably a declining habit in local communities.

In the 1990s on the Gaspé Peninsula, however, the strong growth in the seabird population that occurred in the previous decade had slowed. Over the 13 years between the 1989 and 2002 censuses, the total population increased by only 21% to approximately 279 000 birds (Table 8). Similarly, seabird populations in Migratory Bird Sanctuaries along the St. Lawrence North Shore, which grew strongly in the 1980s, did not fare as well in the 1990s and early 2000s. In eight sanctuaries that were censused in 1988 and again in 2005, the total seabird population actually declined by 7% during that period (Chapdelaine and Brousseau 1991; Rail and Cotter 2007).

While most seabird species (11 of 14) on the Gaspé Peninsula exhibited similar trends between 1979 and 1989, that is, increases of >30%, this was not the situation between 1989 and 2002. Over this period, six of 14 species increased in population by ≥70%, three species decreased in numbers by >35%, and the populations of five remained relatively stable with changes of <15%. The latter group includes the Atlantic Puffin, for whom numbers are too low to assess changes in population size (Table 8).

In each of the 1979, 1989, and 2002 censuses, three species—Northern Gannet, Black-legged Kittiwake, and Common Murre—accounted for over 75% of the total population, and therefore changes in the populations of these species had the main impact on overall seabird population trends. Interestingly, between 1989 and 2002 these three species each exhibited a different trend; the population of the Northern Gannet increased by 122%, that of the Black-legged Kittiwake decreased by 13%, while the population of the Common Murre remained stable (increase of only 3%).

Of the different seabird groups, between 1989 and 2002 the total population of larids declined whereas the populations of alcids and cormorants increased. Three of the five larid species that breed on the Gaspé Peninsula declined sharply (>35%), whereas populations of all alcid and cormorant species either remained stable or increased. Of the remaining three individual species, Common Eiders and Northern Gannets increased in numbers, whereas the small population of Leach's Storm-Petrels declined (there were no active burrows found in 2002). Rail and Chapdelaine (2004) reported a similar pattern in the overall trends of seabirds along the St. Lawrence North Shore between 1993 and 1998-1999. Over that interval, they reported increases in population for four species, decreases for four species, and stable or moderate trends for the remaining species. As we observed on the Gaspé Peninsula in the 1990s, larids along the North Shore declined in numbers whereas populations of alcids and cormorants increased. It should be noted that among larids, the Ring-billed Gull was an exception to the downward trend; it increased considerably in numbers in both regions, with annual growth of 31.0% (1993 to 1998-1999) and 40.0% (1989-2002) for the North Shore sanctuaries (Rail and Chapdelaine 2004) and the Gaspé Peninsula, respectively. The coastlines of both regions are fronted by the Estuary and Gulf of St. Lawrence, which breeding seabirds of both regions use almost exclusively as their foraging grounds. It is not surprising, therefore, that the seabird populations of both regions show similar trends. Strong growth of Ring-bill populations also occurred in the Maritime Provinces, where the population grew at an annual rate of 20.9% between 1972 and 1986 (Lock 1988), and recent censuses in Prince Edward Island (Boyne and McKnight 2005) and New Brunswick (Boyne et al. 2006) have shown that populations in these two provinces have continued to grow.

An interesting observation from our results is the 1989-2002 trend for species that are "surface feeders" as compared with those that are "divers". The proportion of the total seabird population made up of divers increased from 50% in 1989 to 70% in 2002, and conversely the proportion for surface feeders fell from 50% to 30%. A similar pattern has occurred with seabird populations on the Magdalen Islands. In this archipelago, between 1989-1990 and 2000-2002 divers increased by 20% while surface feeders declined by 20% (CWS, unpublished data). This trend seems gen-

eralized throughout the Gulf of St. Lawrence, as within Migratory Bird Sanctuaries of the North Shore the same 20% increase in the proportion of diving species (and 20% decrease of surface feeders) can be noted between 1988 and 2005 (CWS, unpublished data).

For the Gaspé Peninsula, the recent declines in larids, in particular among kittiwakes and terns, as well as the possible extirpation of the Leach's Storm-Petrel, are major concerns for seabird biologists and managers. Factors that may be responsible for the declines, specifically possible changes in productivity, breeding conditions, predators, and/or survival, should be studied. Despite concern for these species, the overall population trends of seabirds along this peninsula are encouraging. The total number of seabirds has doubled between the first comprehensive survey in 1979 and the most recent survey in 2002, with nine of the 14 breeding seabirds showing strong population growth over that period.

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Sixteenth Census of Seabird Populations in the Sanctuaries of the North Shore of the Gulf of St. Lawrence, 2005

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Rail, Jean-François, and Richard Cotter. 2007. Sixteenth census of seabird populations in the sanctuaries of the North Shore of the Gulf of St. Lawrence, 2005. Canadian Field-Naturalist 121(3): 287-294.

The Migratory Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence are important breeding grounds for many seabird species. The quinquennial censuses of seabirds in these sanctuaries have been carried out for 80 years (since 1925), in order to detect changes in the distribution and population levels of seabirds breeding on the North Shore. Between 1998-1999 and 2005, the most striking trends observed were the near doubling in numbers of Common Eiders in most sanctuaries, and the strong population growth rate of Razorbill. Unexplainable declines of Common Murre and Atlantic Puffin were observed at some of the larger colonies of these species. The last active colonies of Leach's Storm-Petrel (Corossol Island) and Caspian Tern (Île à la Brume) on the North Shore seem on the verge of disappearing, with zero and three birds observed in 2005, respectively. Seabird populations in the larger, more accessible and disturbed sanctuaries are still markedly smaller than in historical times.

Les refuges d'oiseaux migrateurs de la Côte-Nord du Golfe du Saint-Laurent constituent d'importants sites de nidification pour plusieurs espèces d'oiseaux marins. Des inventaires quinquennaux des oiseaux marins dans ces refuges sont effectués depuis 80 ans (depuis 1925), pour détecter les changements dans la répartition et les niveaux de population des oiseaux marins nichant sur la Côte-Nord. Entre 1998-99 et 2005, les tendances les plus marquantes étaient chez l'Eider à duvet, dont les effectifs ont pratiquement doublé dans la plupart des refuges, et chez le Petit Pingouin, dont les populations ont également connu une croissance rapide. Des déclins énigmatiques chez le Guillemot marmette et le Macareux moine ont été observés à plusieurs des colonies les plus importantes de ces espèces. Les dernières colonies actives d'Océanite cul-blanc (à l'île du Corossol) et de Sterne caspienne (à l'île à la Brume) sur la Côte-Nord semblent sur le point de disparaître, avec respectivement zéro et trois oiseaux observés en 2005. Les populations d'oiseaux marins demeurent à des niveaux bien en-deçà de ceux rapportés historiquement dans les refuges de grande superficie, davantage accessibles et sujets au dérangement.

Key Words: Seabirds, populations, sanctuaries, Atlantic Puffin, larids, alcids, Gulf of St. Lawrence.

The Migratory Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence not only contribute to seabird conservation by protecting important breeding grounds, but through the quinquennial censuses they serve as monitoring areas to detect changes in the distribution and population levels of 15 species of seabirds (scientific names given in Table 1), which in turn orient future research and management.

Since the creation of the sanctuaries on the North Shore in 1925, seabirds breeding in these sanctuaries have been censused approximately every five years. The results of previous surveys have been consistently published (Lewis 1925, 1931, 1937, 1942; Hewitt 1950; Tener 1951; Lemieux 1956; Moisan 1962; Moisan and Fyfe 1967; Nettleship and Lock 1973; Chapdelaine 1980, 1995; Chapdelaine and Brousseau 1984, 1991; Rail and Chapdelaine 2004). Thus the sixteenth census, conducted in 2005, perpetuated an 80 year-old tradition that constitutes, over time, an invaluable database for the management and conservation of seabird populations in Québec. For some species, a very significant proportion of their total breeding population in the province is found in North Shore Migratory Bird Sanctuaries. Furthermore, many species are represented well enough in these sanctuaries to assume that the observed population trends reflect the demographic changes for the entire North Shore. These censuses of seabird colonies are of even greater importance as for most of our seabirds they are the only means to effectively monitor population trends, because most seabird species are not currently covered by other existing monitoring programs. Ultimately, the integrity of the whole seabird community in the sanctuaries can also be used as a sentinel to track environmental changes and to evaluate the health of the Gulf of St. Lawrence marine ecosystem.

The goals of this article are to update population estimates and trends for seabirds breeding in the ten Migratory Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence, to evaluate the situation of each species, and to identify priority issues for their conservation.

Methods

We used basically the same survey techniques as in 1998-1999 (see Rail and Chapdelaine 2004). The methodology, described in detail for each species and site in Rail and Chapdelaine (2002), is summarized below for each family of birds.

ANATIDS — On Corossol Island, the average nest density (nests/ha) as calculated from six 60 m × 60 m (0.36 ha) quadrats, was extrapolated to the entire area

on the island deemed suitable for Common Eiders (Chapdelaine 1978*). In the Betchouane Bird Sanctuary, we used a system of line-transects of varying length on Innu Island and conducted a systematic nest count elsewhere. In Watshishou and Île à la Brume, we counted all eider nests on the same sample of islands used in previous censuses, which covered 12% and 27% of the sanctuaries' land area, respectively, and we then extrapolated the average density over the entire area encompassing all the islands. At the Baie des Loups Sanctuary, a combination of methods was used: average nest density was extrapolated from two quadrats on Île Les Blacklands, from a sample of islands at Îles Factory, and from the closest island at Île no 4; the remaining islands in the sanctuary were systematically censused. Total nest counts were conducted on most large islands at the Îles aux Perroquets and Îles Sainte-Marie Sanctuaries, representing 57% and 96% of the total land area, respectively; average nest densities were extrapolated to the rest of the sanctuaries. At the Gros Mécatina and Saint-Augustin Sanctuaries we also searched for nests on the largest islands, but for the smaller islands, on which we did not land, we counted from a boat all females that flushed and assumed one nest per female observed.

GAVIIDS — Red-throated Loon nests were systematically counted by walking around the ponds on islands presenting suitable open habitat in each sanctuary. In one instance, instead of landing on the island, we noted the presence of a territorial adult.

HYDROBATIDS — We systematically searched for active burrows where colonies had been found in previous censuses. Traditionally, a burrow was considered active if we detected signs, such as soil freshly excavated and/or oily odour characteristic of petrels, or when we were able to reach an adult inside the burrow. In 2005 we also used in some instances a burrow probe (Peep-A-Roo, Sandpiper Technologies Inc.), which consisted of a 1.0-inch diameter video imager with infrared illumination source, on a 3-meter long flexible cord.

PHALACROCORACIDS — Great and Double-crested Cormorant nests were systematically either from the ground, from a lookout point, or from a boat.

LARIDS — On Corossol Island, we counted the number of nests (Np) and the number of adults (Ni) in subcolonies, then we estimated the number of pairs in sectors where we counted only the number of adults present by using the factor k (k = Np/Ni). In these sectors we applied the observed species ratio (Great Black-backed / Herring Gulls) to the calculated number of nests. All gull nests were counted systematically at the Betchouane Sanctuary, and attributed to Herring and Great Black-backed Gulls afterwards according to the observed proportions of adults of both species. A combination of nest counts, adult counts and species ratios was used elsewhere for gulls and terns, except that results have been combined for Arctic and Common Terns in Table 1. For the Black-legged Kittiwake, we counted apparently occupied nests.

ALCIDS — Adult bird counts were used to estimate Black Guillemot populations in all sanctuaries. When colonies of Common Murres, Razorbills and Atlantic Puffins could be visited with minimal disturbance, we systematically counted the eggs and apparently active burrows. For puffins, we occasionally used the Peep-A-Roo burrow probe (described in the Hydrobatids survey method) to determine the real occupancy rate of apparently active burrows. At many colonies, for example, burrows that were inaccessible in cliffs or featuring large numbers of birds (especially murres), we avoided disturbance by counting from a distance all individuals at the colony and on nearby waters, using binoculars or a spotting scope. At Corossol Island and Gros Mécatina Sanctuaries, only bird counts were used, whereas all eggs and active burrows were noted at the Betchouane Sanctuary. Population estimates for the large concentrations of alcids at the Baie des Loups, Îles aux Perroquets and Îles Sainte-Marie Sanctuaries were obtained mostly from adult counts. For Atlantic Puffins nesting in the Baie des Loups Sanctuary, we used the method described above for larids, that is we calculated the factor k (number of active burrows per individual observed at the colony) for sectors on Île Les Blacklands and Île du Loup and used it to estimate the number of pairs for puffins observed elsewhere. Evenly spaced grids and line transects were used on Île aux Perroquets in the Baie de Brador Sanctuary, in order to (1) delimit the area of both the puffin and Razorbill colonies, (2) evaluate mean nest densities, and (3) extrapolate the calculated density to total colony area (*see* Nettleship 1973* ; Chapdelaine 1978*). Incubating murres were counted on this same island. Also, in the Baie de Brador Sanctuary, numbers of puffins around L'Île-Verte were counted.

Results

The number of seabird species breeding in North Shore sanctuaries remained at 14 between 1998-1999 and 2005, with the reappearance of the Caspian Tern (3 adults) at the Île à la Brume Sanctuary, and the apparent disappearance of the Leach's Storm-Petrel. If we exclude results from the Saint-Augustin Sanctuary (not surveyed in 1998-1999), the estimated total number of breeding seabirds censused in 2005 (n = 107 011 individuals) was very similar to 1998-1999 estimate (n = 103 579; increase of only 3.3%). However, some species showed marked population changes (Tables 1 and 2). In particular, Common Eider numbers doubled in nearly every sanctuary. The Razorbill population also increased greatly in most sanctuaries (overall annual growth rate of +7.3%). On the other hand, the population of Common Murres dropped by half between 1998-1999 and 2005.

TABLE 1. Census of seabirds (number of individuals) in the bird sanctuaries of the North Shore of the Gulf of St. Lawrence 1998-1999 and 2005.

	Île du Corossol		Betchouane		Watshishou		Île à la Brume		Baie des Loups		Îles aux Perroquets		Îles Sainte-Marie		Gros Mécatina		Baie de Brador		Total		Saint-Augustin	Grand Total
Species	1998	2005	1998	2005	1998	2005	1999	2005	1999	2005	1999	2005	1999	2005	1999	2005	1999	2005	1998-1999	2005	2005	2005
Common Eider																						
Somateria mollissima	1162	1960	3088	5596	4754[1]	11024[1]	916	1004	2090	3898	484	866	578	1218		4			13072	25570	146	25716
Red-throated Loon																						
Gavia stellata							2	2	12	6	24	28	42	54	2	2			82	92		92
Leach's Storm Petrel																						
Oceanodroma leucorhoa	718																		718	0		0
Double-crested Cormorant																						
Phalacrocorax auritus	950	312			1078	1688							802	1300		46			2830	3346		3346
Great Cormorant																						
Phalacrocorax carbo											14	2	326	46	2				342	48		48
Ring-billed Gull																						
Larus delawarensis					443	54	41	48				1242							484	1344	549	1893
Herring Gull																						
Larus argentatus	1968	1278	950	1004	831	833	202	454	391	527	187	169	342	206	59	166	58	175	4988	4812	1102	5914
Great Black-backed Gull																						
Larus marinus	1160	658	122	156	185	176	22	52	206	239	95	106	385	169	46	35	206	279	2427	1870	86	1956
Black-legged Kittiwake																						
Rissa tridactyla	3384	3318	170	146							22	14	182	516	40		58		3856	3994		3994
Caspian Tern																						
Hydroprogne caspia								3											0	3		3
Common and Arctic Terns																						
Sterna hirundo																						
Sterna paradisaea					38	331	46	55	32	15	65	81	96	49	100	1789	17	4	394	2324	987	3311
Common Murre																						
Uria aalge	316	522		128					32	187	3593	1598	26156	12131	13	67	14	244	30124	14877		14877
Razorbill																						
Alca torda	815	2197	244	328	8		8		990	1062	2046	5555	7220	8964	388	192	2622	4174	14341	22472		22472
Black Guillemot																						
Cepphus grylle	223	321			43	21	30	25	64	16	124	76	167	223	137	240		2	788	924	4	928
Atlantic Puffin[2]																						
Fratercula arctica	3	6	324	524					8318	1774	1585	620	3020	2208	103	123	15780	20080	29133	25335		25335
Total	10699	10572	4898	7882	7380	14127	1267	1643	12135	7724	8239	10357	39316	27084	890	2664	18755	24958	103579	107011	2874	109885

[1] Important note: it is more than likely that the calculation method used to estimate the eider population in Watshishou results in a significant overestimation (by possibly as much as 3-4 times, but see Rail and Chapdelaine 2002). The reason we used this method was for population trends analysis, e.g. to allow better historical comparisons (results were obtained with the same method in previous censuses).

[2] In 2005, the use of the burrow probe at a few sites at Baie des Loups, Îles aux Perroquets and Baie de Brador verified that apparently occupied burrows were actually used at a fairly constant rate (between 74 and 76%. Thus the puffin populations estimates presented here for these sanctuaries, and for the Îles Sainte-Marie Sanctuary as well, are overestimations because apparently occupied burrow counts were used. We did not apply a correction factor to these estimates so as to be able to better compare with data from previous censuses.

TABLE 2. Changes in the numbers of seabirds in sanctuaries on the North Shore of the Gulf of St Lawrence, Québec, 1993 to 2005.

Species	Years of survey rate by period*			Compound annual growth	
	1993	1998-1999	2005	1993-1999**	1999-2005**
Common Eider	14548	13072	25570	-2.10%	9.98%
Red-throated Loon	66	82	92	3.21%	1.92%
Leach's Storm-Petrel	1840	718	0	-18.38%	-100.00%
Double-crested Cormorant	3472	2830	3346	-3.36%	2.82%
Great Cormorant	78	342	48	24.54%	-32.73%
Ring-billed Gull	104	484	1344	28.43%	21.54%
Herring Gull	4879	4988	4812	0.58%	-0.27%
Great Black-backed Gull	2284	2427	1870	1.27%	-3.79%
Black-legged Kittiwake	6294	3856	3994	-9.98%	0.64%
Caspian Tern	0	0	3	–	100.00%
Common and Arctic Terns	545	394	2324	-10.99%	29.01%
Common Murre	30829	30124	14877	-0.39%	-11.78%
Razorbill	8389	14341	22472	8.58%	7.32%
Black Guillemot	411	788	924	8.90%	2.45 %
Atlantic Puffin	46684	29133	25335	-7.91%	-2.34%

$$*r = \frac{\log_e N(t) - \log_e N(o)}{t} \; 100\%$$

** Data from the Saint-Augustin Sanctuary (censused only in 2005) are excluded from this table, as well as data from the Gros Mécatina Sanctuary (not surveyed in 1993) in the 1993-1999 growth rate calculations. Populations in sanctuaries censused in 1998 were extrapolated to 1999 to derive the compound annual growth rate for all North Shore sanctuaries after 6 years.

Although smaller murre colonies grew substantially in size, the bulk of the population, concentrated at Îles Sainte-Marie and Îles aux Perroquets, suffered an unexplainable and severe decline. In other respects, the sharp decreases in Black-legged Kittiwake numbers that were noted in 1993 and 1998-1999 had finally ceased by 2005 at Corossol Island, the largest colony on the North Shore. The 2005 census also showed that Herring Gull populations were quite stable, whereas Great Black-backed Gulls suffered a 23% overall reduction in numbers compared with 1998-1999. All major Atlantic Puffin colonies showed declines except for the Baie de Brador colony which increased by 27%, and this colony thereby represents the only stronghold of the species in our province.

Corossol Island was visited from 28 May to 30 May. In 1998, the island held the last known colony of Leach's Storm-Petrel on the North Shore (359 active burrows). Unfortunately, no nests were found in 2005. The Double-crested Cormorant colony had 156 nests in 2005, which is only a third of its size in 1998. Conversely, the estimated 980 breeding pairs of Common Eiders in 2005 represent a 69% increase compared to the 1998 count. We found that the rapid decline of Black-legged Kittiwake numbers, noted during the two preceding censuses, had finally stopped between 1998 and 2005. This species is still the most abundant seabird on the island. Alcids in general showed clear upward trends, in particular the Razorbill population which increased by 170% during the 1998-2005 period. Finally, Herring and Great Black-backed Gulls numbers were somewhat reduced in 2005, shrinking back to the levels observed in 1993. The total number of breeding seabirds was similar in 1998 and 2005 at Corossol Island.

On 2 June 2005 the Betchouane Sanctuary was surveyed and Common Eider numbers were found to have had increased by 81% compared to 1998. The observed density of nests was impressive as over one-fifth (21.8%) of the eiders breeding in all North Shore sanctuaries were concentrated in Betchouane, the smallest sanctuary. Alcids also did well between 1998 and 2005; numbers of Razorbills and Atlantic Puffins had risen significantly, and the 64 Common Murre pairs discovered in 2005 were the first breeding record of this species in the sanctuary. Population levels of gulls and kittiwakes were quite stable between 1998 and 2005. The overall number of breeding seabirds increased by more than 60%.

When we visited the Watshishou Bird Sanctuary on 4 and 5 June 2005, we found the Common Eider population had literally exploded since 1998 (+132%). The terns had bounced back with an estimated 331 individuals breeding on ten islands, after very few of these birds were seen in 1998 (n = 38). Three of the four Double-crested Cormorant colonies found in 1998 had grown in numbers in 2005 (+56.6% total increase). Numbers of Herring and Great Black-backed Gulls stayed remarkably stable during the same period. On the other hand, Black Guillemots were less abundant in 2005 than in 1998, and no Razorbills were seen in 2005.Population trends between 1999 and 2005 were

FIGURE 1. Location of the sanctuaries of the North Shore of the Gulf of St. Lawrence.

minor for most species breeding at the Île à la Brume Sanctuary. Even Common Eiders were stable here, whereas spectacular increases were noted for this species in other sanctuaries. The Caspian Tern did a timid comeback with three (presumably) breeding individuals seen in 2005. This species had not been recorded on the two previous quinquennial censuses. Conversely, for the first time since the beginning of the quinquennial censuses in 1925, no Razorbills were seen in this sanctuary in 2005. Only Herring and Great Black-backed gulls exhibited marked positive trends; their small populations grew more than twofold between 1999 and 2005. The Île à la Brume Sanctuary was visited on 9 and 10 June.

The most striking result for the Baie des Loups Sanctuary (visited on 11, 14 and 19 June) was the extremely low number of Atlantic Puffins observed at Île Les Blacklands, an island which has always been well known for its large puffin colony. Data analysis confirmed the catastrophic puffin decline (-79%) between 1999 and 2005 in this sanctuary. Since 1960, the Baie des Loups Sanctuary had never held less than 25% of the total puffin population breeding in North Shore sanctuaries, until this proportion dropped to 7% in 2005. Black Guillemots also had suffered a sharp decline (-75%). Razorbill numbers were similar in 1999 and 2005, in contrast with the general upward trend observed elsewhere for this species during the same period. On the bright side, the small Common Murre population had become firmly established in the sanctuary in 2005 with a near fivefold increase since 1999, and with the appearance of a second colony. Meanwhile, the population of Common Eiders had also risen substantially (+87%).

At the Îles aux Perroquets Sanctuary, the total number of breeding alcids stayed relatively stable between 1999 and 2005, but this is because the Razorbills' large population increase (+172%) compensated for the declines in Common Murres (-56%), Atlantic Puffins (-61%) and Black Guillemots (-39%). The Common Eider population grew by +80%. Meanwhile, Herring and Great Black-backed Gull numbers were nearly stable. Only one of the seven Great Cormorant nests found in 1999 was still active in 2005. Black-legged Kittiwakes seemed also on the verge of disappearing from Îles aux Perroquets, with seven nests left in 2005. The sanctuary was visited on 13 and 22 June.

The Îles Sainte-Marie Sanctuary comprises large islands that hold important concentrations of seabirds, and six days were devoted to their census (15, 17, 18, and 20 to 22 June) in 2005. Alcids showed moderate population trends except for the major drop in Common Murre numbers (-54%), the most abundant seabird in the sanctuary. There were more than twice as many eider nests as in 1999. Between 1999 and 2005, the Black-legged Kittiwake colony at Île Cliff grew unexpectedly (+184%), but other gull populations continued to dwindle in the sanctuary. Such low numbers of breeding Great Black-backed and Herring Gulls had not been seen there since 1950 and 1925, respectively.

The two species of cormorants showed opposite trends. With an 86% drop between 1999 and 2005, the size of the Great Cormorant colony in 2005 (23 nests) was the smallest ever recorded since its establishment in the early 1930s, whereas the Double-crested Cormorant colony increased to 650 nests (+62%).

The Gros Mécatina Sanctuary was surveyed in two stages: the Îles aux Marmettes and Île Plate were visited on 23 June, whereas Île aux Trois Collines could not be accessed before 7 July. This was only the second quinquennial survey of the Gros Mécatina Sanctuary, which was created in 1996. In 2005, two species had disappeared (Great Cormorant, Black-legged Kittiwake) but were replaced by two others (Double-crested Cormorant, Common Eider). The most significant change was in the tern colony at Île Plate which grew from 50 to nearly 900 pairs between 1999 and 2005. Terns now comprise two-thirds of all breeding seabirds in the sanctuary. Also, the small number of Common Murres observed had increased fivefold. Considering the small size of the sanctuary, the growth (+75% between 1999 and 2005) and size (n = 240 in 2005) of the Black Guillemot population were impressive.

Our visit to the Saint-Augustin Sanctuary on 25 June 2005 was the first in 17 years. The last time was at the end of the 1980s, when Herring Gull populations were thriving, and just before a widespread decline was observed on the North Shore. The 2005 census confirmed that this trend also occurred at the Saint-Augustin Sanctuary, as Herring Gull numbers were down 82% compared with 1988. The Great Black-backed Gull population also suffered a 73% decline during the same period. Alcids, represented by a mere four (4) Black Guillemots in 2005, did not show any signs of recovery. Common Eiders, on the other hand, made a noticeable comeback as they were more than ten times more abundant than in 1988. However, considering that the Saint-Augustin Sanctuary has the largest land surface area of all North Shore sanctuaries and the fact that between 1935 and 1960 a minimum of five hundred pairs of eiders were recorded in any one census, the estimate of 73 pairs for 2005 looks far from the potential of these islands. The terns, though, were well represented in 2005, with numerous (n = 13) colonies and a total population of nearly a thousand birds, the largest ever recorded in this sanctuary.

The largest concentration of breeding Atlantic Puffins in the province of Québec has always been located in the Baie de Brador Sanctuary. Fortunately, our results show a 27% increase of that colony between 1999 and 2005, in contrast with the declines observed at other major puffin colonies on the North Shore. Baie de Brador now shelters 79% of all puffins breeding in North Shore sanctuaries. During the same period, the Razorbill population mean annual growth rate was high (6.9%) but similar to elsewhere, and numbers of Common Murres went up by an amazing 50% annually. In other respects, the colony of Black-legged Kittiwakes discovered in 1999 had already disappeared by 2005. We landed on Île aux Perroquets on 30 June and 1 July, whereas L'Île-Verte could not be reached before 12 August.

Discussion

Here we present a short analysis of the latest population trend and current status of each species in the North Shore sanctuaries, in order of species in best health (population) to worst. The Common Eider has to come first on the list. Its population has increased dramatically since 1982, and the near-doubling in numbers between 1998-1999 and 2005 represents a very strong population growth rate. The Common Eider is now the most abundant breeding seabird in North Shore sanctuaries. The Razorbill is another species that has been increasing in numbers for more than 20 years in the sanctuaries (as well as everywhere in Eastern North America, Chapdelaine et al. 2001), and there is no indication that this upward trend will slow. Furthermore, many new colony sites were discovered during this period. The size of the Red-throated Loon population was larger than ever in 2005, particularly due to the high numbers reported in the Îles Sainte-Marie and Îles aux Perroquets sanctuaries. The addition of the latter sanctuary in 1982 helped to protect a significant proportion of this species' small population of only a few hundred individuals spread along the northern coasts of the Gulf of St. Lawrence (DesGranges and Laporte 1979*; Barr et al. 2000; Chapdelaine and Rail 2004). The Black Guillemot has also fared well in the sanctuaries, an exception being at Île à la Brume and Baie des Loups, where breeding numbers have been much higher in the past. Important for the species is the recently created Gros Mécatina Sanctuary (1996); this sanctuary encompasses less than 3% of the total land surface area of North Shore sanctuaries yet it harboured one-fourth of the Black Guillemot population in 2005. The Double-crested Cormorant, the Common and Arctic Tern, and the Ring-billed Gull were species very well represented in North Shore sanctuaries in 2005. However, the trends observed with these species in the sanctuaries may not be representative for the whole North Shore. In fact, the few colonies of Double-crested Cormorants in the sanctuaries show variable and sometimes contrasting trends. And colonies of terns and Ring-billed Gulls are highly unpredictable, too variable in size and localization (in and out of the sanctuaries from one year to another) to derive meaningful trends.

Herring Gull population trends also tended to vary between sanctuaries, but as a whole the North Shore population has been quite stable since the crash that occurred between 1988 and 1993 (which was associated with the collapse of the cod fishery, see Chapdelaine and Rail 1997). In 2005 the species was well established in all sanctuaries. Great Black-backed

Gulls were also well represented in every sanctuary, and leaving aside the 43% decline at Corossol Island, elsewhere the population was stable between 1998-1999 and 2005. Another species showing relative stability in numbers between the last two quinquennial censuses is the Black-legged Kittiwake. At Corossol Island, the only large colony in North Shore Sanctuaries, the sharp declining trend (-58%) observed between 1988 and 1998 had ceased by 2005. Because of this colony's importance for the species on the North Shore and evidence of very poor reproductive success in 2005 and 2006 (CWS, unpublished data), it is imperative that careful monitoring of the colony occurs in the future. Examination of their diet suggests that when staple food (capelin, sandlance) becomes scarce in their diet, the larger gulls (Herring and Great Black-backed gulls) are more likely to prey on kittiwake chicks.

The Common Murre population had expanded so much between 1972 and the 1990s that it was disappointing to see this recent setback (51% decline between 1998-1999 and 2005) which brought the population back to the level observed in 1982. The Common Murre is still the fourth most abundant bird in the sanctuaries, but the underlying factors responsible for the substantial population decline at the largest colonies are not known and will need to be investigated if the species declines in number any further. The Îles Sainte-Marie holds the only well-established Great Cormorant colony in North Shore sanctuaries. The number of nests, which once peaked at 339 (in 1955), has been highly variable since 1993. We can only hope that numbers will bounce back after the lowest number of nests ever recorded there was in 2005, otherwise the species may well disappear from the sanctuaries in the near future. The Atlantic Puffin is not on the verge of vanishing from the sanctuaries; however, its situation is worrying, as the larger colonies located at Baie des Loups, Îles aux Perroquets, Îles Sainte-Marie and Baie de Brador declined by 47% between 1993 and 2005. The 79% decline in six years (1999 to 2005) at Baie des Loups is particularly mysterious, and the colony at the Baie de Brador sanctuary, currently the species' stronghold in the province of Québec, appears vulnerable to disturbance, poaching and bycatch in fishing nets. The fact that three Caspian Terns were observed in 2005 in the Île à la Brume Sanctuary, the only active breeding site in the province, confirms that a small number of individuals of this species continues to frequent the area. We suspect that a few pairs may still breed there sporadically, but it is doubtful that such a tiny population can persist for long if no recovery plan is implemented (but see Shaffer et al. 2004). The first active burrows of Leach's Storm-Petrels were discovered in 1972 in the Baie des Loups Sanctuary. In the censuses that followed, the species was found in three other sanctuaries, with a total of close to 900 burrows in 1982 and 1988. Inexplicably, storm-petrels vanished as fast as they appeared and in 2005 not a single nesting site was found at the last active colony, Île du Corossol. We have no reason to believe that the (unknown) factors responsible for the loss of this species will be reversed in the future.

We identified sanctuaries that seemed in worse shape by comparing the 2005 seabird numbers with historical data in each sanctuary. Some current seabird populations estimates are markedly lower than in historical times. For example, the Île à la Brume Sanctuary once protected a fair number of alcids, including up to 2000 pairs of Common Murres (in 1935). These species declined and never recovered, and in 2005 only a few pairs of Black Guillemot were still breeding in the sanctuary. Alcid populations had also been much larger in the past at the Baie des Loups Sanctuary. At the Saint-Augustin Sanctuary, population levels of Common Eider, Black Guillemot and Red-throated Loon seem far from the potential showed in the 1940s. Moreover, while the Île à la Brume and Saint-Augustin Sanctuaries together represent 40% of the total land area of the ten North Shore sanctuaries, only 4.1% of the seabirds were found there. Of course, seabird populations also reflect habitat features, and these two sanctuaries may not have habitats such as cliffs and deep crevices that are most suitable for kittiwakes and murres. But even the Common Eider, which in 2005 was abundant in similar habitat in Watshishou, was rather rare in the Île à la Brume and Saint-Augustin sanctuaries as they harboured only 2.2% of the total North Shore sanctuaries population. Besides, we saw evidence of eider egg collection in the Saint-Augustin sanctuary in 2005. In these sanctuaries that are comprised of a large number of islands and are easily accessed by boat from nearby villages, the poor density of breeding birds is likely the result of a lack of law enforcement and public awareness the vulnerability of seabird breeding colonies. In addition to improvements in law enforcement and educational programs in local communities, priorities for seabird conservation in North Shore sanctuaries should include population studies to identify the underlying causes of the unexplained declines in Atlantic Puffins and Common Murres and a restoration project for the Caspian Tern colony at Île à la Brume.

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Discovery of a Possibly Relict Outbreeding Morphotype of Sparrow's-egg Lady's-slipper Orchid, *Cypripedium passerinum*, in Southwestern Yukon

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An outbreeding morphotype of *Cypripedium passerinum* with separate anthers and stigma was discovered in the Beringian region of southwesternYukon. The occurrence of this breeding system in Beringia is attributed to the persistent advantage of outbreeding over hundreds of thousands of years in this unglaciated area, whereas the widespread occurrence of exclusively self-pollinating races elsewhere in Canada is attributed to advantages in colonization of recently deglaciated territory which first became available less than 10 000 years ago, and/or to a changing and more forested habitat.

Key Words: Sparrow's-egg Lady's-slipper Orchid, *Cypripedium passerinum*, Orchidaceae, autogamy, self-pollination, unglaciated, Beringia, Kluane, Yukon.

In fresh flowers of Sparrow-egg Lady's-slipper Orchid (*Cypripedium passerinum* Richards.), the lateral parts of the stigma are in contact with the anther allowing self-pollination (Figure 1A). Self-pollination is evident by a mass of pollen tubes connecting the expanded anther tightly to the stigmatic surface. It occurs when the flowers are still in bud or before they are fully open and germination of pollen prevents subsequent removal by pollinators resulting in little chance for cross-pollination. This obligate self-pollination is widespread (Catling 1983; Catling, personal observation) in the geographic range, which extends from Quebec west across the boreal forest and montane region of Canada to Alaska (Sheviak 2002; Figure 2). Plants that do not self-pollinate have not been observed prior to the observations reported here.

An examination of long-faded and shrivelled flowers, clearly past peak flowering, collected in alcohol on 13 July 2006 from the Alsek River trail (60.7748°N, -137.6939°W, approximately 10 km west of Haines Junction) in the Kluane Range, St. Elias Mountains of southwestern Yukon, revealed that self-pollination had not occurred in 7 of 8 flowers removed from a clump of 30. In most of these flowers self-pollination was prevented because the anthers were clearly separated from the stigmatic surface (Figures 1B-C) but in one flower they were touching but without self-pollination (Figure 1D) and the anthers were bowed so that most of the length of the suture was not in contact with the stigmatic surface. In one of these flowers self-pollination had occurred apparently due to contact of anther and stigma (Figure 1E). All eight of the flowers from this clump were presumably from one individual and suggest variation in self-pollination at the individual level. A voucher specimen (*Catling & Bennett*, 13 July 2006) from the Alsek River location has been placed in the National Collection (acronym — DAO) of Agriculture and Agri-Food Canada on the Central Experimental Farm in Ottawa.

Ten long-faded flowers collected from several individual plants south of Whitehorse at Cowley Creek (60.5908°N, 134.8953°W) were self-pollinated (Figures 1F-H) and so were three flowers collected from a location near Mayo (not illustrated). In one of the flowers from Whitehorse an anther was sufficiently separated that self-pollination had not occurred (Figure 1F). Although only the distal tip of the anther suture appeared to contact the stigmatic surface in most specimens, in one flower (Figure 1G) the proximal part had also come in contact, with the result that pollen tubes entered the stigma from both anther tips. Self-pollination in orchids is frequently partial or facultative (e.g., Catling 1990). In western Yukon there may be substantial variation in column morphology leading to variation in amounts of self-pollination, both within individuals and between plants. This variation may have provided the basis for the selection of obligate self-pollinating morphotypes that are now widespread.

Selection for self-pollination may have favoured a number of characteristics including: (1) more extensive development of the lateral parts of the stigmatic surface; (2) less divergence of the anther stalks; (3) less elongation and curvature of the column resulting in less displacement of the anthers above the stigmatic surface; (4) increased bowing of the anthers to bring the tips of the suture into contact with the stigmatic sur-

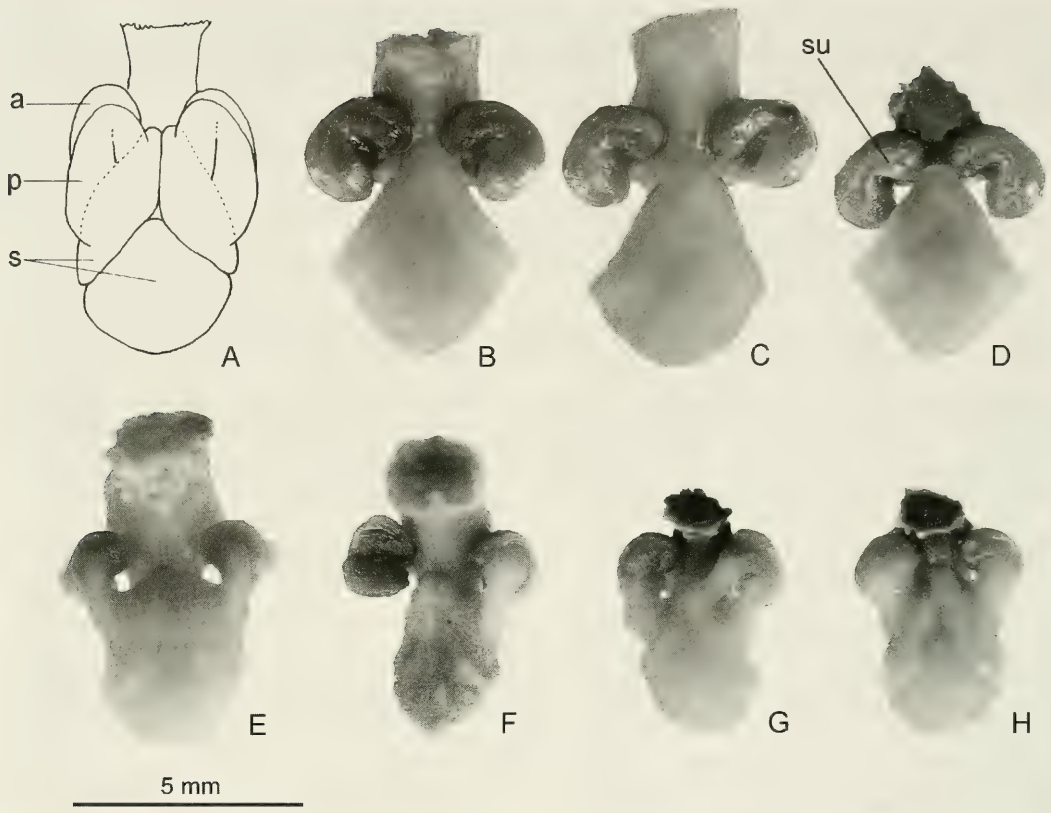

FIGURE 1. Columns of *Cypripedium passerinum* viewed from below showing anthers (a), pollinia (p), stigmatic surface (s) and suture of anther (su). A, camera lucida drawing of flower from Hattie Cove, Lake Superior, Ontario (modified from Catling 1983); B-E flowers from Alsek trail, Kluane Range, Yukon; F-H, flowers from south of Whitehorse, Yukon. Columns A and E-H demonstrate self-pollination with one or both anthers connected to the stigmatic surface by a mass of pollen tubes. Columns B-D have not self-pollinated.

face; and (5) increased secretion of stigmatic fluid which would connect the anther and the stigma. Regardless of how the flowers have changed to promote self-pollination, both the separation of anther and stigma, and the lack of self-pollination in old flowers are novel observations suggesting outbreeding in a species that was hitherto known only to obligately self-pollinate.

The structure related to breeding system in *C. passerinum* is difficult to discern in reconstituted pressed herbarium specimens and softening the few flowers on a specimen to evaluate it results in damage to the specimen. As a consequence, an investigation of herbarium material was not conducted. The examination of fresh plants from at least 20 localities (Catling, personal observation) across Canada, including Ontario (3 locations), Manitoba (1 location), British Columbia (8 locations), Alberta (2 locations) and Northwest Territories (6 locations) is believed to reliably indicate the predominance of the obligately self-pollinating morphotype outside of the Beringian region (Figure 2). Nevertheless, more research on the geographical occurrence and related morphological and anatomical aspects is needed to better understand the evolution of self-pollination in this species, and to provide a basis for consideration of formal taxonomic recognition.

Self-pollination originates through evolution by natural selection from cross-pollinated plants (e.g., Catling 1990). In general, self-pollination in orchids is more frequent in cooler and more extreme environments such as recently glaciated territory (Catling 1983, 1990). This is believed to be a consequence of strong selection for colonizing ability, the selfing plants being able to set seed in the absence of others of their kind and/or in the absence of pollinators and being able to mass produce adapted genotypes. This would have been advantageous in colonizing huge areas of land (most of northern North America) exposed following melting of the Wisconsin ice sheets less than 10 000 years ago (Dyke 2005). It may also be advantageous within Beringia as a consequence of the change from pollinator-rich willow (*Salix* spp.) scrub and tundra to

FIGURE 2. Distribution of *Cypripedium passerinum* in northwestern North America (dots) and location of plants with non-auto-pollinating column structure on Alsek River (circle). The unglaciated region of Beringia is darkly shaded (redrawn from Dyke 2005). The dot distribution of *C. passerinum* was copied from Cody (1996), Hultén (1968), Packer (1959), Porsild and Cody (1980), and Szczawinski (1959).

a pollinator-depauperate boreal forest that occurred between 9000 and 5000 ka kiloannum BP (Dyke 2005). As a result of the strong selection, self-pollinating morphotypes are presumed to have evolved from cross-pollinated ancestors in unglaciated territory, and these new selfers spread over the newly available or recently changed landscape. Many self-pollinating orchids have a non-self-pollinating relative that has a more restricted range in a region of more temperate climate and/or longer established habitat. Examples in North America include self-pollinating *Liparis loeselii* which is widespread north of the range of the non-self-pollinating *Liparis liliifolia*, and self-pollinating *Spiranthes ovalis* var. *erostellata* which is widespread north of the more restricted distribution of *Spiranthes ovalis* var. *ovalis* (see Catling 1990 for other examples).

The occurrence of a non-self-pollinating race of *Cypripedium passerinum* in the northwestern part of the range rather than the warmer southern or southeastern part of its range is at first contrary to expectation. However, in this example a relict outbreeding morphotype may have existed for hundreds of thousands of years in the unglaciated Beringian area of Alaska and western Yukon (Figure 2 and see Scudder 1997). It may have been from this source that morphotypes more committed to self-pollination spread southward and eastward following deglaciation 10 000 years ago. The present distribution of *Cypripedium passerinum* fits what Hultén refers to as "North American boreal plants radiating from Beringia." (Hultén 1937, see also Cody 1971 and Ritchie 2003). It is possible that the outbreeding ancestral morphotype of *Cypripedium passerinum* is a Beringian relict. In Beringian habitats that have existed for hundreds of thousands of years, and presumably include pollinators, cross-pollination was likely advantageous. *Cypripedium passerinum* presently occurs in *Alnus crispa* or *Betula glandulosa* shrubland habitats that are believed to have existed in Beringia during full glacial times (e.g., Hopkins 1982; Ritchie and Cwynar 1982; Cwynar 1990; Cwynar and Spear 1991; Lacourse and Gajewski 2000) when the rest of Canada was covered by ice up to a few km deep. *Cypripedium passerinum* also occurs in open aspen (*Populus*) and spruce (*Picea*) woodland. Both of these species evidently existed in isolated valley-bottom habitats within the Beringian steppe plateaus, although *Populus* pollen does not preserve well making its widespread but isolated occurrences more difficult to detect (Zazula et al. 2006; Zazula, personal communication). *Cypripedium passerinum* also occurs in parts of the north, to 68°N, where Beringian species are predominant. As it spread from Beringia across the rest of northern Canada into new, recently deglaciated territory, there

was likely a strong selection for self-pollination, this explaining the apparent predominance of self-pollinating morphotypes.

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Twenty-Four-Hour Activity Budgets of Mule Deer, *Odocoileus hemionus*, in the Aspen Parkland of Eastcentral Alberta

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We documented seven 24-h activity budgets of two adult Mule Deer (*Odocoileus hemionus*) does without fawns in the Aspen Parkland of Alberta when the vegetation was green (June, July), maturing (September) and cured (October). They spent about 40% (mean = 42.3%) of each day foraging, somewhat more when vegetation was green (40-47%) and maturing (45%), and less time in October, when the vegetation was cured (38-39%). The percentage of time Mule Deer were bedded each day generally equaled or slightly exceeded (33-53%) that of foraging. Walking was a prevalent activity (3-24%), especially in autumn and little time was invested in other activities such as social interactions and grooming (1-4%). There were generally more feeding bouts (10-16/day) than bedding bouts (4-10/day) per day, and feeding bouts were shorter (37-68 minutes) than bedding bouts (69-133 minutes). Mule Deer displayed polycyclic feeding cycles with slight increases in feeding activity near dawn and dusk.

Key Words: Mule Deer, *Odocoileus hemionus*, activity, foraging, Alberta.

Mule Deer (*Odocoileus hemionus*) range over much of western North America, yet little is known about their foraging ecology on northern ranges (Kuzyk 2008), especially regarding their daily activities. Documenting how much time Mule Deer spend feeding during different stages of vegetation phenology provides insight into behavioral adaptations in seasonal northern environments. Browsing ruminants normally spend about 50% each day foraging, with feeding times varying with forage phenology, morphological and physiological characteristics such as mouth shape, gut capacity and food passage rate (du Toit and Yetman 2005). Activity budgets can be used to quantify daily foraging times and other major activities. One difficulty in conducting activity budgets is remaining close enough to a focal animal to accurately quantify activity patterns, especially during darkness. Using tame deer is one way to maintain consistent visual contact with a focal animal for a 24-h period (Collins and Urness 1983) and provides reliable results, as food intake in tame deer is deemed innate (Spalinger et al. 1997). Maintaining visual contact with tame deer also allows daily feeding cycles and duration of feeding bouts to be quantified.

The purpose of this study was to quantify activity budgets of Mule Deer on northern ranges when the vegetation was green (June and July), maturing (September) and cured (October). From allometric considerations (Mysterud 1998; du Toit and Yetman 2005), we predicted that Mule Deer would spend 50% of their daily activity budget foraging and foraging time would change with forage phenology. We predicted that Mule Deer would spend least time foraging in summer when vegetation was green and the most time in autumn when the vegetation had cured because required selectivity increases search time.

Methods

Our study animals were two unbred adult Mule Deer does which were hand-reared as fawns. The animals were four and six years old and weighed 59 and 60 kg, respectively, at the beginning of the study. These animals would allow researchers to remain within five meters of them, apparently without disturbing their normal activities. The deer were released into 3-7 hectare fenced enclosures (2.2 m high) in an Aspen Parkland habitat (Strong 1992) at the University of Alberta Ranch (53°N, 111°31'W) approximately 150 kilometers southeast of Edmonton, Alberta. Each deer was instrumented with a radiocollar (Telonics TGW-3570) and placed in a paddock with two other Mule Deer as part of a larger study (Kuzyk 2008). This study was approved by the University of Alberta Faculty Animal Policy and Welfare Committee (Protocol HUDS 2004–33B), following guidelines of the Canadian Council on Animal Care.

Scan sampling (Altmann 1974) was conducted on focal deer throughout one complete 24-h period and repeated seven times during the summer and autumn of 2004 and 2005 (Table 1). One Mule Deer (501H) was used for six of the sampling periods and was substituted for another Mule Deer (515K) to compare behaviors at the same season but different years (Table 1). Only one 24-h activity budget was conducted per sampling period. The activity budget was classed into predominant activities and recorded every 10 minutes (Collins and Urness 1983). One observer closely followed

TABLE 1. Activity budgets (24-h) for one Mule Deer doe (501H) at the University of Alberta Ranch, Kinsella, Alberta.

Date		Feeding		Bedding		Walking		Other	
		% day	hrs	% day	hrs	% day	hrs	% day	hrs
2005	June 9	40.8	9.8	50.0	12	6.3	1.5	2.9	0.7
2004	July 13	41.7	10	47.9	11.5	6.3	1.5	4.2	1
2005	July 7	47.1	11.3	47.1	11.3	3.3	0.8	2.1	0.5
2004	September 11	45	10.8	32.5	7.8	21.7	5.2	0.8	0.2
2005	September 9	44.6	10.7	38.3	9.2	15.8	3.8	1.3	0.3
2004	October 8	38.8	9.3	36.7	8.8	23.8	5.7	0.8	0.2
2005*	October 12	38.3	9.2	52.9	12.7	7.1	1.7	2.1	0.5

* Note: Different Mule Deer (515K).

the deer and used a stopwatch to time predominant activities within a 10-minute bout. An activity had to occur for 5 minutes or longer within a 10-minute time interval to be classed as predominant. Predominant activities were feeding, bedding, walking and other (social interactions, grooming). Feeding was defined as ingesting, chewing or intently searching (smelling plants) for food, while walking was defined as a deer moving without biting vegetation. Ruminating was associated with bedding. Each observer spent between 6 and 10 hours with the Mule Deer and overlapped shifts by approximately 15 minutes to minimize disturbance to the deer. At night, a flashlight was used to monitor the Mule Deer by concentrating the light beam on the posterior portion of the body to minimize disturbance.

Daily patterns of feeding and bedding were determined by the number and duration of bouts that were separated by at least 10 minutes (Pépin et al. 2006). Daily feeding cycles were evaluated by the proportion of time spent feeding each hour over a 24-hr period. The proportion of time spent feeding at dawn and dusk was determined by the mean amount of time spent feeding 1-3 hours before, 1 hour before and 1 hour after and 1-3 hours after sunrise and sunset (Colman et al. 2001). Descriptive analyses of activities are presented due to insufficient sample sizes for statistical comparisons.

Results

Mule Deer spent about 40% of each day foraging with slight increases when the vegetation was green and maturing (40-47%) and less time when the vegetation was cured (38-39%). Mule Deer spent between 33-53% of each day bedded (Table 1). Feeding bouts were generally shorter (37-68 min) than bedding bouts (69-133 min) and there were more feeding bouts (10-16/day) than bedding bouts (4-10/day) per day (Table 2). Feeding cycles were polycyclic (Figure 1) with increased feeding activity near sunrise and sunset (Figure 2).

Discussion

Our research documented and compared daily foraging activities of Mule Deer on a northern range when the vegetation was at three phenological states, and deer were at successive stages of their annual growth cycle. Our findings did not meet our prediction that Mule Deer would spend less time foraging in summer than in autumn. We assumed abundant forage quantity and quality would account for reduced foraging activity in summer, but early summer is the period when weight gain and appetite are greatest, despite the absence of milk production for fawns. Possibly Mule Deer were being very selective in forage quality in the summer period and spent more time consuming the

TABLE 2. Number and duration (mean min/bout ± SE) of feeding and bedding bouts for one Mule Deer doe (501H) during 24-h periods at the University of Alberta Ranch, Kinsella, Alberta.

Date		Feeding		Bedding	
		Bouts/24-hr	Min/bout	Bouts/24-hr	Min/bout
2005	9 June	16	36.9 ± 5.5	10	72.0 ± 16.5
2004	13 July	15	40.0 ± 8.7	10	69 ± 11.6
2005	7 July	10	68.0 ± 10.6	6	113 ± 15
2004	11 September	12	54.2 ± 11.5	4	117.5 ± 29.3
2005	9 September	11	58.2 ± 11.3	5	110 ± 27.6
2004	8 October	13	43.1 ± 9.0	4	132.5 ± 41.7
2005*	12 October	12	45.8 ± 9.4	7	108.6 ± 11.0

* Note: Different Mule Deer (515K).

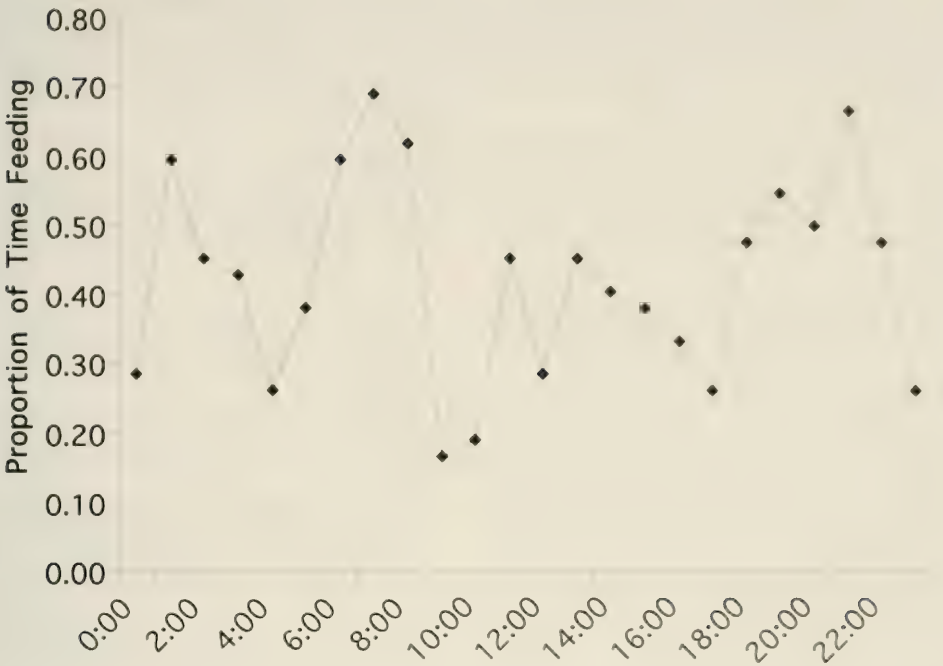

FIGURE 1. Feeding cycles of adult Mule Deer does in the Aspen Parkland of east-central Alberta. Data are averaged and pooled for season (June, July, September, October) and years (2004-2005).

FIGURE 2. Proportion of time a Mule Deer doe spent feeding 1-3 hours before, 1 hour before and after, and 1-3 hours after sunrise and sunset in the Aspen Parkland of east-central Alberta. Data are averaged and pooled for season and years (2004-2005).

easily digestible forbs when they were readily available. In September, Mule Deer may have increased foraging times as the vegetation started to senesce and deer spent more time searching for green vegetation, especially forbs beneath the grass layer.

Mule Deer spent the least time foraging in October when the vegetation had cured. This may be due to Mule Deer adjusting their bite sizes (Kuzyk and Hudson 2006) to compensate for the lack of green vegetation. Mule Deer on northern ranges have high consumption rates (g/min) in October and can forage at rates that are near theoretical maximum by feeding on Canadian thistle (*Cirsium arvense*) (Kuzyk and Hudson 2006). Increased bite sizes in October could lead to a quicker gut fill compared to other seasons.

The percentage of time Mule Deer bedded each day equaled or exceeded that of the time spent foraging. High diurnal temperatures can reduce Mule Deer activity (Hayes and Krausman 1993), especially during midday (Ager et al. 2003), and could account for the difference. Beir and McCullough (1990) found that White-tailed Deer (*Odocoileus virginianus*) were relatively inactive in summer when feeding on abundant forage. Long bedding bouts may reflect requirements for rumination of coarse forage.

There was variation in behaviors between the two Mule Deer in October in different years. Time spent foraging was almost identical, whereas the time spent bedding contrasted greatly as the individual used in multiple trials (501H) spent 36.7% of the day bedding compared to 52.9% for the other individual (515K). Also, 501H spent substantially more time walking (24%) than did 515K (7%), which may be due to individual variations in behaviors.

Mule Deer had polycyclic feeding cycles which has been determined for some other northern ungulates (Colman et al. 2001). The cycles may be driven by rumen fill and time required for digestion (Pérez-Barbería and Gordon 1999), as these Mule Deer experienced little disturbance and few intra-specific interactions (Kuzyk and Hudson 2007). Mule Deer increased feeding activity near sunrise and sunset which is similar to the behavior of White-tailed Deer (Beir and McCullough 1990), as crepuscular activity is a common behavior for small ruminants to reduce predation risk (Pérez-Barbería and Gordon 1999). There appeared to be a more pronounced feeding peak at sunrise, possibly due to rapid daytime heating in summer and fall or increased insect harassment. Additional studies quantifying activity budgets of Mule Deer would help clarify determining factors of daily feeding cycles.

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Cavity Nest Materials of Northern Flying Squirrels, *Glaucomys sabrinus*, and North American Red Squirrels, *Tamiasciurus hudsonicus*, in a Secondary Hardwood Forest of Southern Ontario

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Through deployment of artificial nest boxes, we examined the composition of cavity nest materials used by Northern Flying Squirrels (*Glaucomys sabrinus*) and North American Red Squirrels (*Tamiasciurus hudsonicus*) in a secondary hardwood forest of southern Ontario, Canada. We collected 32 nests of known species association and found that 85.7% of *G. sabrinus* nests and 77.8% of *T. hudsonicus* nests were constructed almost entirely of shredded bark from Eastern White Cedar (*Thuja occidentalis*). Mean nest depth across all samples was 12.2 cm and showed no significant difference between species or between spring and summer nests. We review the antiparasitic properties of *T. occidentalis* and suggest that the use of shredded cedar bark by *G. sabrinus* and *T. hudsonicus* to line nest cavities may be a behavioural adaptation, which reduces ectoparasite loads in the nest environment.

Key Words: Northern Flying Squirrel, *Glaucomys sabrinus*, North American Red Squirrel, *Tamiasciurus hudsonicus*, ectoparasites, nest box, nest material, nest-protection hypothesis, thermoregulation, Eastern White Cedar, *Thuja occidentalis*, Ontario.

Tree cavities are a critical resource for many tree squirrels in forest ecosystems, providing sites for raising young, avoiding predators, and improving thermoregulation (Collias 1964; Weigl 1978; Wiebe 2001). Tree cavities are generally most abundant in old growth forests where large diameter trees and well-decayed snags are commonplace (Holloway and Malcolm 2006; Holloway and Malcolm 2007). Cavities also may form in live trees where the entry of rot has been facilitated by disease, deformities, broken limbs or woodpecker excavations. Where tree cavities are not readily available, many tree squirrels use external nests (dreys) or subterranean nests, although evidence is emerging that tree cavities are preferentially selected when available (Bakker and Hastings 2002). Nest materials used in cavity nest construction may not only act to increase ambient temperature in the nest environment and provide comfort for nest occupants, but may also reduce ectoparasite loads and repel moisture in these dark, damp microclimates (Stapp et al. 1991; Hemmes et al. 2002.) However, despite their importance, tree cavities and cavity nests are rarely incorporated into studies of tree squirrels (Fokidis and Risch 2005).

The nocturnal Northern Flying Squirrel (*Glaucomys sabrinus*) and the diurnal North American Red Squirrel (*Tamiasciurus hudsonicus*) are both occasional cavity nesting, arboreal rodents common in temperate and boreal forests of North America. Both species are primarily associated with conifer-dominated forests, although in many areas of eastern North America they inhabit hardwood and mixed hardwood-conifer forests (Flyger and Gates 1982; Holloway and Malcolm 2006; Patterson 2008). Both *G. sabrinus* and *T. hudsonicus* have been found to use cavities in trees more intensively than external or subterranean shelters, especially for natal nests (Layne 1954; Bakker and Hastings 2002; Holloway and Malcolm 2007).

Nest materials used by arboreal squirrels have been found to vary geographically (Muul 1974). However, most reports describing nest materials employed by squirrels have been qualitative in nature and have focused on dreys. *Tamiasciurus hudsonicus* dreys have been noted to include grape bark, deciduous leaves, dried grasses, moss, feathers, fur and soft inner bark (Layne 1954). Similarly, dreys of *G. sabrinus* have been found to consist of dried grasses, shredded bark, mosses, twigs and lichens (Rust 1946; Mowrey and Zasada 1984). Cavity nests have been described quantitatively only once for *G. sabrinus* (Hayward and Rosentreter 1994). Using nest boxes, these authors found that *G. sabrinus* in the northern Rocky Mountains of central Idaho and western Montana primarily constructed cavity nests from arboreal lichens, especially of the genera *Bryoria* and *Letharia*. We are not aware of studies that have quantified cavity nest materials of *T. hudsonicus*; however, Hayward and Rosentreter (1994) suggest a preference for grasses and shredded bark. Published data on *G. sabrinus* and *T. hudsonicus* nest materials, and associated seasonal differences and depths, in the Great Lakes-St. Lawrence forest region of eastern North America do not exist. In general, the study of nest material use and function in mammals has

received very little attention by researchers and thus warrants investigation.

In order to gain a more complete understanding of the habitat requirements for *G. sabrinus* and *T. hudsonicus* in northern secondary hardwood forests, we characterize cavity nest materials used by these two species in a large network of nest boxes in southern Ontario, Canada. We hypothesized that *G. sabrinus* and *T. hudsonicus* would preferentially select nest materials that favoured cavity nest occupation (i.e., parasite reduction, moisture repellency). Nest depth measurements were investigated as a function of the type of nest material and season (spring and summer); we also assessed seasonal variation in nest material composition. We predicted that nest depths would exhibit interseasonal variability if nest construction was primarily to enhance thermoregulation, such that deeper nests would be constructed under colder temperature regimes. Given the prevalence of shredded cedar bark in the nests of both *G. sabrinus* and *T. hudsonicus,* we discuss the potential antiparasitic and thermoregulatory benefits of Eastern White Cedar (*Thuja occidentalis*) bark.

Study Area

The study was conducted in Bruce and Grey counties, Ontario, Canada (43°59' to 45°12'N, 80°22' to 81°39'W), which together encompass an area of about 22 000 km^2. Nest boxes were placed in trees growing at various elevations, ranging from approximately 200 m to 450 m above sea level. Approximately 22% of the landscape is currently composed of closed-canopy secondary forests, which are dominated by Sugar Maple (*Acer saccharum*), White Ash (*Fraxinus americana*) and American Beech (*Fagus grandifolia*). Other common tree species include Eastern White Cedar, Eastern Hemlock (*Tsuga canadensis*), aspen (*Populus tremuloides, P. grandidentata*) and White Birch (*Betula papyrifera*) (Patterson 2008). Small stands of Eastern White Pine (*Pinus strobus*) and spruce (*Picea glauca, P. mariana, P. rubens*) occur throughout the area, often in plantations.

Materials and Methods

A total of 266 nest boxes were installed between 2002 and 2004 as part of a larger study being conducted by SJP on *G. sabrinus*. Sampling effort varied among years due to logistical constraints. In 2002, 154 boxes were installed; an additional 36 boxes were installed in 2003 and the final 76 boxes were installed in 2004. All nest boxes were placed at heights of 3-4.5 m on trees that had a diameter at breast height >17 cm. Following Carey (2002), nest boxes were established at a density of three nest boxes/ha to allow for a balance between occupancy rates and monitoring effort. Three or more boxes were placed at each of 70 sites across the study region.

Boxes were constructed following Sonenshine et al. (1973), except for the door which was top mounted and could be flipped up to remove any animals and nest material. Our entrance hole was also of larger diameter (4 cm) to permit use by *G. sabrinus* and *T. hudsonicus,* but exclude Eastern Grey Squirrels (*Sciurus carolinensis*). All boxes were mounted to the tree trunk and any tree branches were removed from below the nest box.

All boxes were intensively checked twice per year during the day: once in the spring and once again in autumn. Spring checks were conducted between 12 May and 12 June following the onset of parturition, whereas autumn checks were conducted between 12 October and 12 November. Cursory visual nest box inspections were conducted monthly to monitor the condition of the boxes, but no sampling was done on these occasions. These visual inspections indicated that neither *G. sabrinus* nor *T. hudsonicus* used the nest boxes in late autumn and winter (early December – late February), presumably because individuals abandoned the nest boxes for larger, better insulated natural cavities or subnivean nests. Therefore, nests found at the spring inspection had been constructed between early March and the date of inspection in spring (hereafter termed "spring" nests), whereas those found at the autumn inspection had been constructed between the spring and autumn inspection dates (hereafter termed "summer" nests). Where nests were present and occupied at time of inspection, we recorded the location, number and reproductive condition of occupants and nest depth. Samples of nest material were collected from all nests for identification of materials. In cases where the nest box was not occupied at the time of inspection, the entire nest was removed. In cases where the nest box was occupied at the time of inspection (14% of the nests), a small sample of nest material was initially removed and the entire nest was subsequently removed during targeted monthly nest box examinations following the departure of nest occupants. We removed nest material not only to examine nest materials, but also because Hayward and Rosentreter (1994) observed that nest boxes were typically not occupied in successive years if used nest material was present. Nest depth was always determined during the initial investigation and measured *in situ* along the vertical dimension from the internal base of the nest box to the top of the nest. Nest volume was determined by multiplying the nest depth by the internal width and length dimensions of the nest box.

Results

Nest Box Occupation

Between 2002 and 2005, we found 224 occupied and unoccupied nests. Of these, 32 were occupied when checked (14 *G. sabrinus* and 18 *T. hudsonicus*). Females were found occupying the nest boxes in 12 cases for *G. sabrinus* and 14 cases for *T. hudsonicus*. Lone males were occasionally found occupying the nest boxes (two *G. sabrinus* and four *T. hudsonicus*).

Nest Materials of *G. sabrinus* and *T. hudsonicus*

Twelve of the 14 boxes occupied by *G. sabrinus* and 14 of the 18 boxes occupied by *T. hudsonicus* contained >90% shredded cedar bark by volume. One *G. sabrinus* nest was composed entirely of fibreglass insulation and another was composed of >80% shredded deciduous bark. Trace amounts of peat moss, dried grasses, cedar leaves and twigs also were found in occupied *G. sabrinus* nests. Two *T. hudsonicus* nests were composed entirely of dried grasses and two nests contained >80% deciduous leaves. Trace amounts of shredded plastic, bird feathers, animal fur, dried grasses and deciduous leaves also were found in occupied *T. hudsonicus* nests.

Nest materials did not appear to differ between seasons ($t = -1.892$, $P = 0.06$), with shredded cedar bark appearing as the most prominent nest material in both spring (84.5%) and summer (79.3%). Small sample sizes for male nests did not allow for robust comparisons between male and female nest materials.

Nest Depth

Mean depth of nests occupied by *G. sabrinus* was 12.1 cm (SD = 2.4, range = 6.7 to 15.3 cm) and for *T. hudsonicus* was 12.3 cm (SD = 2.1, range = 9.1 to 17.8 cm), although the difference was not statistically different ($t = 0.31$, $P = 0.76$). We found no statistical difference between spring (*G. sabrinus* mean = 11.9 cm; *T. hudsonicus* mean = 12.6 cm) and summer (*G. sabrinus* mean = 11.1 cm; *T. hudsonicus* mean = 12.7 cm) nest depths for either species for occupied nests (*G. sabrinus*: $t = 0.55$, $P = 0.30$; *T. hudsonicus*: $t = 0.17$, $P = 0.43$). Small sample sizes for male nests did not allow for robust comparisons between male and female nest depths.

Discussion

The prominence of cedar bark in *G. sabrinus* and *T. hudsonicus* nests may be explained by at least two, nonmutually exclusive, hypotheses: nest-protection and thermoregulation. The nest-protection hypothesis has received much attention from ornithologists to explain the use of green vegetation in avian nests. Initially suggested by Wimberger (1984) and tested by Clark and Mason (1985), the nest-protection hypothesis posits that animals exploit the antiparasitic properties of certain plant species that emit specific volatile compounds (Dawson 2004). All plants contain secondary metabolites that are used as a defense against disease and herbivory (Clark and Mason 1988) and, when these plants are used as nesting materials, certain compounds may reduce ectoparasite loads in the nest environment. Numerous studies have supported the nest-protection hypothesis in birds (Wimberger 1984; Rodgers et al. 1988; Fauth et al. 1991; Lafuma et al. 2001). The nest protection hypothesis has found support on at least one occasion for small mammals: Hemmes et al. (2002) reported that Dusky-footed Wood Rats (*Neotoma fuscipes*) placed California Bay (*Umbellularia californica*) leaves around their nest sites. Laboratory tests revealed that when incubated with torn *U. californica* leaves for 72 h, survival of flea larvae was reduced by 74% compared to controls. By using shredded Eastern White Cedar bark as a primary nest material, *G. sabrinus* and *T. hudsonicus* also may be limiting exposure to nest-borne ectoparasites. Phytochemical analysis of *T. occidentalis* bark has revealed 22 volatile compounds, including monoterpenes, fenchene, camphene, camphor, carvacol and paracymene (Shaw 1953; Witte et al. 1983; Yatagai et al. 1985; Keita et al. 2001), several of which have noted antiparasitic or insecticidal properties (Adams et al. 1988; Adams 1993; Keita et al. 2001).

Support for the nest protection hypothesis is bolstered by the use of lichens in nests of *G. sabrinus* found in western North America. Antiparasitic effects have been described for several species of lichen. Hayward and Rosentreter (1994) found that *G. sabrinus* selected lichens containing the secondary compounds norstictic acid, fumarprotocetraric acid, vulpinic acid and atranorin, all of which have been attributed with varying degrees of antiparasitic or antimicrobial effects (Giez et al. 1994; Tay et al. 2004; Yilmaz et al. 2004). These various studies support the possibility that the use of *T. occidentalis*, as well as several lichen species, by *G. sabrinus* and *T. hudsonicus* may be a behavioural adaptation for ectoparasite control in the nest environment. Further testing of the antiparasitic effects of *T. occidentalis* volatile oils and secondary compounds on known *G. sabrinus* and *T. hudsonicus* ectoparasites is required.

An alternative hypothesis is that shredded cedar bark may offer greater insulative properties than other available materials. Hayward and Rosentreter (1994) suggested the same hypothesis when characterizing the primary use of lichens as nest material by *G. sabrinus*. This hypothesis is based on the finding by Stapp et al. (1991) that nests composed of plant fibres allowed Southern Flying Squirrels (*Glaucomys volans*) to reduce their energy expenditure when experimentally subjected to cold temperatures. We are not aware of studies on the thermal properties of cedar bark, lichens or other nest materials found in this study. A common assumption is that nest materials with greater thermal properties are favoured, and/or that nest depth would peak, during colder periods. Contrastingly, we found that shredded cedar bark was used equally in spring and summer and that nest depth did not vary between the two seasons. This suggests that cedar bark may not be chosen solely for thermoregulatory purposes; however, we are unable to reject the thermoregulation hypothesis outright without further empirical testing.

We dismiss a third potential hypothesis that squirrels choose the most widely and readily available materials for use as nest substrate. Patterson (2008) found that deciduous trees accounted for approximately 80% of the tree composition in our study area by basal area,

while Eastern White Cedar accounted for less than 10% of the total forest composition on average, by basal area. Deciduous leaves and deciduous tree bark are therefore more greatly available than *T. occidentalis* bark in our study area. At some sites where cedar bark nest material was found to occur, Eastern White Cedar trees accounted for only 2% or less of the total tree composition (Patterson 2008). On one occasion during this study we observed a single female *G. sabrinus* travel over 500 m to the nearest *T. occidentalis* tree to acquire cedar bark for nest construction. Mosses, lichens, and grasses are also widely available throughout the study area (J. Patterson, unpublished data) and yet were rarely found as nest materials in this study.

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Depredation of Common Eider, *Somateria mollissima*, Nests on a Central Beaufort Sea Barrier Island: A Case Where No One Wins

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Along the central Beaufort Sea, Pacific Common Eiders (*Somateria mollissima v-nigra*) nest on unvegetated, barrier islands; often near nesting Glaucous Gulls (*Larus hyperboreus*). Nest-site choice likely reflects a strategy of predator avoidance: nesting on islands to avoid mammalian predators and near territorial gulls to avoid other avian predators. We observed a nesting colony of Common Eiders from first nest initiation through nesting termination on Egg Island near Prudhoe Bay, Alaska (2002 – 2003). Resident gulls depredated many eider nests, mostly during initiation. All nests failed when an Arctic Fox (*Alopex lagopus*) visited the island and flushed hens from their nests, exposing the eggs to depredation by the fox and gulls (resident and non-resident). Common Eiders actively defended nests from gulls, but not from foxes. Likely all three species (i.e., eiders, gulls, and foxes) ultimately achieved negligible benefit from their nest-site selection or predatory activity: (a) island nesting provided no safety from mammalian predators for eiders or gulls, (b) for Common Eiders, nesting near gulls increased egg loss, (c) for Glaucous Gulls, nesting near colonial eiders may have reduced nest success by attracting the fox, and (d) for Arctic Foxes, the depredation was of questionable value, as most eggs were cached and probably not recoverable (due to damage from fall storms). Thus, the predator-prey interactions we observed appear to be a case where little or no fitness advantage was realized by any of the species involved.

Key Words: Arctic Fox, *Alopex lagopus*, Common Eider, *Somateria mollissima*, Glaucous Gull, *Larus hyperboreus*, nest depredation, predator-prey interaction, Beaufort Sea, Alaska.

Along the central Beaufort Sea, nest success of Pacific Common Eiders (*Somateria mollissima v-nigra*) is highly variable, with egg depredation by Glaucous Gulls (*Larus hyperboreus*) and Arctic Foxes (*Alopex lagopus*) being the primary cause of nest failure (Johnson and Herter 1989; Johnson 2000). Common Eider nest-site choice on coastal barrier islands is thought to reflect a strategy of predation avoidance. Typically, Common Eiders nest in colonies, often within the territory of nesting gulls (Noel et al. 2005). By nesting on islands, Common Eiders may avoid mammalian predators such as foxes (Johnson 2000; Noel et al. 2005). By nesting near gulls, eiders may benefit from territorial defense by gulls (Bourget 1973; Schamel 1977; Götmark and Åhlund 1988; Fournier and Hines 2001), but may incur additional risk if the resident gulls depredate their nests. If the depredation rate exceeds the gulls' protective benefit, then Common Eiders could be experiencing an unsustainable situation similar to the "ecological trap" described by Dwernychuk and Boag (1972).

As part of a larger study of Common Eider breeding ecology, we conducted an intensive observational study of nesting biology on Egg Island, near Prudhoe Bay, Alaska. Our primary objective was to replicate the study by Schamel (1974, 1977) and document the behavioral interactions among Common Eiders and nest predators with minimal researcher disturbance.

Methods

We selected Egg Island for this study because data from annual surveys showed relatively consistent concentrations of Common Eider nests (Noel et al. 2005) and a similar observational study of Common Eider reproduction had been conducted there in the 1970s (Schamel 1974, 1977). Egg Island is a small unvegetated island that is part of the chain of barrier islands that form Simpson Lagoon (Noel et al. 2005). Prior to Common Eider nest initiation in 2002 and 2003, we erected elevated observation blinds near the main colony. In 2002, we used two blinds with 30 m above-ground plywood access tunnels, and in 2003 we used one blind with a 25 m access tunnel. The blinds were 1.2 m × 1.2 m × 1.5 m plywood boxes raised 2.5 m above the ground. Observers accessed the island in small boats, using the tunnels to hide our approach. Boating was limited to a single landing and departure per day and there was no observer activity on Egg Island outside of the tunnels and blinds. Common Eiders were never observed to flush while we accessed the blinds. However, the entrance of one tunnel in 2002 was near three Glaucous Gull nests. These gulls often flushed as we approached, but remained near their nest-site and returned to the nest quickly after we entered the blind.

With few exceptions due to poor weather, we recorded daily nest observations during blocks of 4-6 × 1 h

observation sessions. We staggered our observation blocks to cover the entire 24-hour period, because, at the latitude of our study site, the sun does not set during the entire nesting period. We conducted observations from initiation of the first eider nest until incubation at all nests terminated each year. During observation sessions, we mapped all nests within view of the blinds and recorded the amount of time each nest was occupied. We recorded all interactions with predators and, each hour, we performed 15 min predator watches during which we counted all aerial and ground patrols by avian predators. We tallied these counts to create an index of avian predation pressure.

We considered a nest to be a site in which at least one egg was seen or a site that was occupied by a hen during observations for > 24 h. We considered incubation to have begun when a hen was seen on a nest full-time after at least three consecutive days of attendance. Nests were deemed failed when no eider was seen using the site on two consecutive days. Nests occupied > 24 h after an observed depredation event were counted as partial depredation, whereas nests abandoned shortly after depredation were considered to be completely depredated (i.e., entire clutch loss). To estimate inter-nest distances, we visited each nest site after all nesting birds left the island and recorded coordinates with a GPS unit. All means are provided ± SE.

Results

We conducted 126 h of observations on 16 days (15 June – 3 July) in 2002, and 140.5 h of observation on 23 days (19 June – 13 July) in 2003. We observed 45 Common Eider and 10 Glaucous Gull nests in 2002, and 37 Common Eider and 9 Glaucous Gull nests in 2003. Gull nest initiation preceded eider nest initiation by several days. The majority of Glaucous Gull nests were already in the incubation stage when observations began each year, whereas the median initiation dates for Common Eiders were 23 June and 25 June, in 2002 and 2003, respectively. In both years, eider and gull nesting periods were terminated prior to hatch when a single Arctic Fox accessed the island and destroyed all nests during the incubation stage.

Gull Predation

We conducted 328 avian predator patrol watches. Glaucous Gulls were the most common predator; other avian predators (jaegers, *Stercorarius* spp., and Ravens, *Corvus corax*) were seen on only seven occasions. The search rate by gulls appeared similar each year ($\bar{x}_{\text{patrols/h}} = 17.2 \pm 1.6$ in 2002, and 14.1 ± 1.0 in 2003), but the search technique changed between years. In 2002, 68.2% ± 3.0 of patrols were aerial, while in 2003 aerial patrols accounted for only 32.9% ± 2.7 of the total. Concurrently, the mean distance between eider nests and the nearest Glaucous Gull nest decreased significantly ($t_{67} = 3.58$, $P < 0.001$) from 75.8 m ± 4.3 in 2002 to 35.2 m ± 9.2 in 2003. This shift in Glaucous Gull patrols may reflect variation in the distance between Common Eider and Glaucous Gull nests between years.

Prior to the fox arrival in 2002, 42% (19 of 45) of attempted Common Eider nests had failed and, in 2003, 70% (26 of 37) had failed but the observation period lasted 10 days longer in 2003. The daily failure rates of 1.2 nests/day in 2002 and 1.3 nests/day in 2003 were similar. Glaucous Gull depredation was the likely cause of all of these failed nests. We directly observed Glaucous Gull depredation in 7 and 11 cases, in 2002 and 2003, respectively. Most nests were lost during the egg laying stage; however, some nests were also destroyed during incubation (4 in 2002, 10 in 2003). Proximity to gull nests appears to have been important in nest failure. Fifty percent and 75% of Common Eider nests < 30 m from gull nests failed in 2002 and 2003, respectively. In 2003, more nests ($n = 20$) were within 30 m of gull nests than in 2002 ($n = 4$). From the blinds, we were unable to see into nests, and thus could not quantify clutch size or proportional egg loss. Yet, in 2003 we did see 38 individual eider eggs eaten by gulls; of these, 14 were taken by Glaucous Gulls known to be nesting in the midst of the Common Eider colony (10 eggs were taken by a single pair of nesting Glaucous Gulls).

Partial predation was uncommon, as Glaucous Gulls typically removed all eggs once they gained access to a nest. We observed six cases of partial predation (4 Common Eider eggs, 2 Glaucous Gull eggs) across years. In one case, a Glaucous Gull pressured a pair of Common Eiders for 41 min before finally stealing an egg from beneath the hen. During this encounter, the hen never moved from the nest and did not indicate awareness of the egg loss. The attending drake actively attempted to defend the nest. In another instance, a Glaucous Gull pulled nest material from under an incubating hen, but was unable to remove any eggs. We never observed a Glaucous Gull displace a Common Eider from a nest.

Common Eiders took attendance breaks throughout the nesting period, averaging 8.2 ± 1.3 min/break based on 57 breaks of known length. Across years, Glaucous Gulls attempted to depredate nests during nearly one quarter (i.e., 21) of the 86 observed attendance breaks, and were successful in half of their attempts (11 of 21). Regularly, we observed Glaucous Gulls standing within 1 m of occupied Common Eider nests. On five of these occasions the incubating hens left their nests unattended; only two returned to successfully defend their nest.

Common Eiders showed three defense strategies against Glaucous Gulls in this study: (1) passively ignoring harassment and sitting tight on nests, (2) actively nipping/lunging at nearby gulls from occupied nests (35% of active behaviors), and (3) actively chasing gulls from their nest after leaving it unoccupied for an

attendance break (65% of active behaviors). The male Common Eider nest defense described earlier was not a singular event; rather, while attending females at nest sites, males often played an active role in defense. Male attendance of females during nest prospecting and initiation was high (for the three days prior to peak initiation in 2002 and 2003, 24% and 71% of active nests were attended by males) then tapered through early incubation. Across years, males were involved in 13 of 15 observed nest defense events prior to 29 June and 0 of 8 defenses thereafter.

Fox Predation

In both years, a single Arctic Fox gained access to Egg Island during the incubation period. On 3 July 2002 it arrived and departed across ice floes and on 13 July 2003 it swam at least one km to Egg Island from a nearby island and left by swimming toward the mainland (> 2 km away). In both cases, the fox was responsible (directly or indirectly) for the destruction of all nests that were active at the time of arrival. The entire fox visit to Egg Island was observed in 2002 (duration = 3 h 11 min) but not in 2003. When observers arrived in 2003 (after a 37 h absence due to weather conditions) the fox was still on the island, but all nests had been destroyed. There were 32 active nests (26 Common Eider, 6 Glaucous Gull) on the island when the fox arrived in 2002, and in 2003 there were 18 active nests (11 Common Eider, 7 Glaucous Gull) during the last observation prior to the fox visit.

When the fox arrived in 2002, there were approximately 30 non-resident Glaucous Gulls loafing on Egg Island in addition to the resident Glaucous Gulls from the six active nests. During observations in 2002, Glaucous Gulls with nearby nests attacked the fox, whereas the other gulls searched through the unprotected nests (both eider and gull) and ate the contents of all eggs encountered. Some gulls ate egg contents at the nests, but others carried eggs up to 20 m away before consuming them.

The fox observed in 2002 cached the vast majority of eggs that it encountered, eating only one gull egg, one eider egg, and the contents of a Snow Bunting (*Plectrophenax nivalis*) nest. It cached at least 34 eider and 4 gull eggs, taking on average 2.3 min to find an egg, cache it, and find another egg. Eggs were carried 20-100 m from the nest and buried 2-5 cm deep in areas of open sand or gravel. We do not have clutch size data from Egg Island; however, the mean Common Eider clutch size from neighboring islands in 2002 was 2.6 eggs/nest. Given this estimate, the fox took approximately 56% of the Common Eider eggs on the island, while the remaining eggs were eaten by Glaucous Gulls.

Resident Glaucous Gulls actively attacked and harassed the fox, but the fox was never seen to leave a site or egg as a result of an attack. Common Eiders never defended their nests from the fox; rather, they flushed from their nest when the fox approached to within 20 m.

Discussion

None of the three species observed in this study appeared to have gained fitness from the use of Egg Island or from interactions on the island. In fact, it appears that they all may have fallen into a situation similar to an "ecological trap". That is, each was enticed by initial conditions (or expectation of conditions) which could have confered a fitness benefit, but due to changes in those conditions, the final result was the loss of fitness.

Glaucous Gulls nested earlier than Common Eiders and may have chosen nest sites on Egg Island in anticipation of Common Eider nests as a potential source of prey or in an attempt to avoid mammalian predators. Regardless, Common Eiders, ultimately, established their nests near existing Glaucous Gull nests. Our results suggest that proximity to Glaucous Gull nests increased avian depredation risk for Common Eiders. Similar to the results of Schamel (1977), the majority (71%) of eider nests were depredated when located within 30 m of gull nests.

On the barrier islands of the central Beaufort Sea there is little vegetation, and the sparse driftwood provides minimal concealment for incubating birds (Noel et al. 2005). Female Common Eiders taking incubation breaks seem to be obvious to nearby gulls, as one-third of our observations of a Glaucous Gull predation event were apparently cued by the eider leaving for an incubation break. Although Common Eider incubation breaks were generally short and probably infrequent (Bolduc and Guillemette 2003; Swennen et al. 1993), our observations indicate that the detection of any break by a Glaucous Gull could lead to the loss of an entire clutch. Female Common Eiders generally fast through the entire nesting period (Korschgen 1977; Bolduc and Guillemette 2003; Swennen et al. 1993), but several authors have noted the physiological importance of drinking periodically throughout incubation (Bolduc and Guillemette 2003; Criscuolo et al. 2000). Thus, it appears that eider hens were forced to trade current reproductive effort for survival and future reproductive potential. It is notable that attending male Common Eiders probably did not increase nest detection substantially, as Common Eider hens were already visible to Glaucous Gulls nesting nearby, and males were, in fact, able to provide additional nest defense in several cases.

Predators, too, failed to gain a fitness benefit during this study. There was no successful Glaucous Gull reproduction in either year. As the fox and non-resident gulls were, most likely, attracted to Egg Island by the concentration of Common Eiders, it appears that Glaucous Gulls, too, fell into an "ecological trap." Common Eider nests were highly vulnerable to depredation by locally nesting Glaucous Gulls (a single nesting pair of Glaucous Gulls consumed over one quarter of all eggs we saw eaten in 2003), so it follows that Common Eider eggs were an important food

source for breeding Glaucous Gulls on Egg Island. Yet, when unprotected eggs were most available (i.e., during the fox visit), non-resident gulls consumed the majority of eggs (including gull eggs), while breeding gulls were occupied with defense of their own nests. Ultimately, these locally breeding Glaucous Gulls failed reproductively, in spite of the apparent benefit of nesting in proximity to Common Eider nests.

Ultimately, Arctic Foxes caused the complete nest loss for all birds in this study, yet the fitness gained by the foxes was likely minimal. The foxes cached almost all the eggs and departed the island shortly after all nests were destroyed. It is doubtful that the cached eggs were ever recovered. To return to the island later in the season to retrieve cached eggs, foxes would face a longer, more arduous, swim due to continued sea ice retreat. Further, the barrier islands of the central Beaufort Sea experience substantial wave-battering and redistribution of sand and gravel from storms during the ice-free period. Thus, it is unlikely that intact cached eggs could be recovered even if the foxes returned to the island later in the season or after freeze-up.

Our results demonstrate that successful Common Eider and Glaucous Gull reproduction in the central Beaufort Sea can occur only in years when foxes do not have access to the barrier islands and even then nesting success of eiders is likely to be low (Quinlan and Lehnhausen 1982). Island access by foxes is unpredictable and can occur during any stage of nesting. These particular foxes were probably non-breeders as they were roaming the islands in July when breeders would be attending mainland dens. The number of non-breeding foxes fluctuates year-to-year; however, in the oilfields around Prudhoe Bay the degree of fluctuation has been dampened (Burgess 2000) and the number of fox dens and the average litter size have increased (Ballard et al. 2000; Burgess 2000). For this eider-gull nesting association to have evolved, the historical access of foxes to island nesting colonies must have been relatively rare (Ahlèn and Andersson 1970). These associations cannot persist on the barrier islands of the central Beaufort Sea if nesting success is consistently driven to near zero by a changed system in which the frequency of Arctic Foxes access to the islands is increased.

Despite the total nest failure caused by foxes, our observations provide information regarding rates of nest depredation by gulls in the absence of human disturbance. Gulls destroyed a fairly high proportion of nests during the egg-laying period, and some of these failed-early nests (often characterized by minimal down or nest bowl delineation) would probably go undetected by researchers searching for nests weeks later during the incubation stage. This has important implications for studies of nesting effort and success involving incubation-stage nest searches, as a bias against the detection of failed nests would lead to biased estimates of these parameters. Overall, even in the absence of human disturbance, the nesting productivity of Common Eiders on the barrier islands of the central Beaufort Sea is low due to the impact of avian and mammalian predators.

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Management Implications of Molt Migration by the Atlantic Flyway Resident Population of Canada Geese, *Branta canadensis*

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We used satellite-tracked transmitters in 2001 and 2003 to document the timing, location, and extent of molt migrations by female Canada Geese (*Branta canadensis*) affiliated with the Atlantic Flyway Resident Population (AFRP) of Canada Geese that breed in the temperate region of eastern North America. Twenty-seven adult females were captured during the nesting period in late May and fitted with a satellite transmitter mounted either on a plastic neck collar or backpack harness. Nests of 24 birds were destroyed late in incubation to prevent renesting and ensure nest failure; three females did not have nests. Twelve of the 27 birds (44%) made a northward migration to molt in northern Quebec, Canada: seven to the eastern coast of Hudson Bay (58°12'N, 76°60'W), three to lowland areas east of James Bay (53°30'N, 79°02'W), and two to interior locations south of Ungava Bay (55°54'N, 68°24'W). Molt migrants were present in northern Quebec from June to September, a period that coincides with breeding ground aerial surveys and banding operations conducted for Atlantic Population (AP) Canada Geese that breed in this same region of northern Quebec. With >1 million AFRP geese estimated in the Atlantic Flyway, the potential exists for substantial numbers of yearling, sub-adult, and nest-failed or non-breeding adults to molt migrate to northern breeding areas and bias efforts to survey and mark AP geese. Within AFRP breeding areas, many local flocks have reached nuisance levels. We hypothesized that by inducing molt migration in breeding adults, through destruction of nests late in incubation, we would lessen recruitment, reduce numbers of summer resident adults with young, and increase adult mortality from hunting. However, molt migration behavior was not uniform throughout our study area. Molt migrants were from rural areas in New York, Pennsylvania, and Vermont, whereas marked birds that did not make molt migrations were from more coastal regions of the flyway. The 14 birds that did not make a molt migration remained within 60 km of their banding site. A genetic comparison of these two groups revealed no detectable differences. We conclude that failure to undergo a molt migration is likely attributed to the historical origin of captive-reared birds of mixed subspecies that comprise AFRP flocks in the eastern regions of the flyway and the availability of quality local habitat, distinct from brood-rearing areas, for molting.

Key Words: *Branta canadensis*, Canada Geese, molt migration, temperate-nesting, Resident Population, Atlantic Flyway.

Canada Geese (*Branta canadensis*) often undergo a late spring migration, flying long distances from their breeding locations to more northerly areas, where they undergo an annual molt. A form of molt migration, these movements have been documented for Canada Geese from both subarctic-nesting populations, which typically breed in remote areas of northern Canada (Sterling and Dzubin 1967; Abraham et al. 1999), and temperate-nesting populations, that breed in southern Canada and the United States (Zicus 1981; Davis et al. 1985; Lawrence et al. 1998). Birds that undergo a molt migration are primarily nonbreeding subadults and unsuccessful breeding adults (Salomonsen 1968; Lawrence et al. 1998).

There are two subarctic-nesting populations (Atlantic Population [AP] and North Atlantic Population [NAP]) associated with the states of the Atlantic Flyway, whereas temperate-nesting geese are collectively recognized as the Atlantic Flyway Resident Population (AFRP; Atlantic Flyway Waterfowl Council 1999*). Because these populations are mostly indistinguishable when they mix in the field on migration routes and wintering locations, their population and harvest management depends on monitoring efforts directed at their population-specific breeding areas. For example, annual assessments of population size are dependent on spring aerial surveys of breeding areas. However, movement of molting groups of temperate-nesting geese from Michigan to subarctic breeding areas in northern Canada has been confirmed through monitoring with satellite-tracked transmitters (Mykut et al. 2004). If molt migrations by temperate-nesting geese occur while spring surveys are being conducted on northern breeding grounds, then population estimates for subarctic-nesting populations can be positively biased by the inclusion of molt migrants (Abraham et al. 1999).

Similarly, population-specific assessments of harvest rely on band recoveries obtained from birds marked on their breeding grounds as flightless adults and young. In recent years, recaptures on subarctic breeding grounds of previously banded adults and young from temperate-nesting areas (Abraham et al. 1999; Nichols et al. 2004) have raised concern over the potential bias in the banded samples of subarctic-nesting geese. Molt migrations of temperate-nesting geese to northern breeding areas can also increase competition for resources and potentially degrade brood-rearing habitat for subarctic-nesting geese. Previous studies have demonstrated that a large proportion (50% – 60%) of temperate-nesting flocks potentially undergo a molt migration (Zicus 1981; Lawrence et al. 1998). Given that estimated numbers of temperate-nesting geese currently exceed 1 million birds in each of the Mississippi and Atlantic flyways (United States [U. S.] Fish and Wildlife Service 2007*), the potential problems with survey efforts and impacts to habitat could be substantial.

Temperate-nesting Canada Geese also are of concern within their breeding range, where they often occur in areas with few natural predators. Because of their relatively high survival and stable reproductive rates, local flocks can rapidly reach nuisance levels in urban areas and rural areas with low harvest pressure. Given that some unsuccessful breeders undergo a molt migration, we reasoned that deliberate nest destruction late in the incubation period, to ensure nest failure, would induce these birds to molt migrate. This procedure has the potential to reduce annual recruitment of young into the population, lessen the number of adults and young residing in local areas during the summer, and expose this component of the population to hunting pressure in other regions when they return in the fall. Our objective was to assess both the efficacy of this technique and to monitor the resultant timing, locations, and extent of molt-migration movements as they relate to management of AFRP Canada Geese in the Atlantic Flyway.

Methods

In 2001, eight female Canada Geese were captured at four locations in New York during late May (Table 1). Nests of five birds were destroyed during the last 7-10 days of incubation; no nests were detected for three of the eight (Table 1). Each goose was fitted with a 30 g satellite-tracked transmitter (PTT Model 100, Microwave Telemetry, Inc., Columbia, Maryland; mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government) attached dorsally with a harness constructed of Teflon ribbon. Transmitters had specifications for ~480 hours of battery life and were programmed to transmit for an eight-hour period every four days. Expected battery life was about eight months.

We expanded the study in 2002 to include 19 nesting females captured under similar nesting conditions in New York (n = 4), Pennsylvania (n = 6), New Jersey (n = 4), Massachusetts (n = 2), Connecticut (n = 1), Vermont (n = 1), and Maine (n = 1). To simplify attachment procedures and reduce costs, we switched to transmitters mounted on plastic neck collars produced by Telonics, Inc. of Mesa, Arizona. Program features were similar to those used in 2001. Unfortunately, most of the transmitters deployed in 2002 did not provide sufficient signals to the satellites to produce usable locations. The 2002 transmitters were replaced by the manufacturer and 19 nesting females were marked in 2003: New York (n = 4), Pennsylvania (n = 4), New Jersey (n = 4), Massachusetts (n = 2), Connecticut (n = 2), Vermont (n = 1), Maine (n = 1), and Maryland (n = 1) (Table 1).

Data from the radio transmitters were obtained from the Argos satellite system of the French Space Agency via a preferential tariff agreement with the U. S. Department of Commerce's National Oceanic and Atmospheric Administration. Location estimates were classified by Argos based on their estimated accuracy and the number of transmissions received from a transmitter during a satellite overpass. Location classes 3, 2, and 1 had accuracy ratings within 1000 m. Accuracy for location class 0 was >1000 m, and location classes A and B did not receive enough transmissions during an overpass for accuracy to be estimated (Service Argos 1996*). However, Britton et al. (1999) demonstrated that poor locations (classes 0, A, and B) received from satellite transmitters (30 g) averaged 35 km from the true location of the transmitter. We therefore included all locations with a classification of 3, 2, 1, 0, A, or B, because the accuracy of these classes was sufficient to describe large-scale movements.

Argos estimated locations by measuring the Doppler shift of the received signals, which produces two pairs of latitude and longitude coordinates from an individual satellite overpass. Argos designates the location with the better frequency continuity as the most probable location (location 1), and the alternate location is designated as the image (location 2). Examination of our data occasionally indicated that sometimes location 2 was a more probable fix than location 1 based on the flight dynamics of Canada Geese. We developed a sorting routine similar to that of Britton et al. (1999) that sequentially examined the location pairs to identify locations that appeared most probable. The initial location for each bird was the site of banding. For each subsequent pair of locations, flight speed (distance/hr) was calculated from location 1 in the previous location pair to location 1 of the next location pair. If the bird had flown <65 km/hr to reach both locations 1 and 2, we selected location 1. If the bird had flown >65 km/hr to reach location 1, but <65 km/hr to reach location 2, we selected location 2. If both locations violated our 65 km/hr rule, we deleted both. We retained all locations with an accuracy classification of 3, 2, and 1. When an 8-hour transmission period contained only locations with a classification of 0, A, and B, we esti-

mated one location for that period as the centroid of the most probable latitude and longitude coordinates.

During the course of our study, we hypothesized that the differential propensity to undergo a molt migration could be related to genetic differences among geese from interior and coastal areas comprising our sample. In 2004, we attempted to test this by collecting blood samples from molting adult geese with young in rural areas of central New York (n = 15) and Pennsylvania (n = 15) and compared these with similarly collected samples from more coastal and urban/suburban areas of Long Island, New York (n = 5), New Jersey (n = 15), Massachusetts (n = 5), and Connecticut (n = 5). Genetic testing of microsatellite markers and mitochondrial DNA was done using methods described by Scribner et al. (2003a).

We used seven microsatellite loci that have previously been described for Canada Geese for other populations across North America (Scribner et al. 2003a, 2003b). Loci included TTU-CG-1, TTU-CG-5 (Cathey et al. 1998) and Bcaμ7, Bcaμ9, Bcaμ11, and Hhi1, (Buchhollz et al. 1998), and CRG (Baker, unpublished data). After electrophoresis on denaturing 6% acrylamide gels, PCR products were visualized using an FMBIO II laser scanner (Hitachi Software Engineering Co., Alameda, California). Genotypes were scored based on 20 base-pair standards and reference samples of known allelic size.

We obtained sequence information from a ≈ 385 base-pair (bp) fragment of the 5' end of the Canada Goose mitochondrial DNA control region using primers and conditions described in Pearce et al. (2000). Sequencing was performed using a SequiTherm Excel DNA sequencing kit (Epicentre, Inc.), following product protocols for use of fluorescently labeled primers. Sequences were aligned manually.

We estimated degree of differentiation in allele and haplotype frequency between Canada Geese sampled from coastal and interior regions using a Fisher's exact test in program GENEPOP and using F-statistics (Weir 1996) using the program F-STAT (Goudet 1995). Measures of inter-population variance in allele frequency were summarized as pair-wise estimates of population F_{st}. Significance of mean F_{st} values (across the seven loci) were determined by jack-knifing procedures (Weir 1996). Analyses of population differences in mtDNA haplotype frequency were conducted using an analysis of molecular variance (Excoffier et al. 1992).

Results

Of the eight birds marked in New York in 2001, seven made molt migrations to areas in Quebec, Canada: four traveled to the eastern coast of Hudson Bay (58°12'N, 76°60'W), two went to lowland areas east of James Bay (53°30'N, 79°02'W), and one moved to an interior location ~350 km southwest of Ungava Bay (56°06'N, 70°04'W) (Figure 1). Locations from four transmitters deployed in 2002 (two from Pennsylvania, one from New York, and one from Vermont) suggested that these birds also made a molt migration to northern Quebec; however, the data were not sufficient to identify migration timing or provide reliable locations.

TABLE 1. Bird identification numbers, state and year of banding (cohort), latitude and longitude of banding location, and approximate distance between banding and molting location (km). Females with no nest are identified with an (*).

ID	Cohort	Banding location		km
		latitude	longitude	
33115	NY-2001	43°06'N	78°30'W	1122
33116*	NY-2001	43°06'N	78°24'W	897
33117	NY-2001	42°12'N	78°54'W	1830
33118	NY-2001	42°06'N	78°36'W	1295
33119*	NY-2001	41°36'N	74°06'W	1641
33120	NY-2001	41°36'N	74°06'W	≤60
33121*	NY-2001	42°42'N	75°30'W	1941
33122	NY-2001	42°42'N	75°30'W	1725
19873	CT-2003	41°20'N	71°32'W	≤60
19874	PA-2003	40°39'N	77°45'W	1830
19875	MD-2003	38°35'N	76°07'W	≤60
19876	CT-2003	41°32'N	73°04'W	≤60
19909	ME-2003	44°43'N	68°54'W	≤60
19911	MA-2003	41°37'N	71°06'W	≤60
19916	MA-2003	41°17'N	71°27'W	≤60
19922	NJ-2003	40°42'N	74°30'W	≤60
19923	NJ-2003	40°25'N	74°29'W	≤60
19930	NJ-2003	39°35'N	75°29'W	≤60
19932	NJ-2003	41°00'N	74°09'W	≤60
19934	NY-2003	41°05'N	73°51'W	≤60
19940	NY-2003	42°50'N	73°50'W	1573
19955	NY-2003	40°45'N	73°07'W	≤60
19957	NY-2003	40°37'N	73°15'W	≤60
19962	PA-2003	39°48'N	80°03'W	1396
19973	PA-2003	40°07'N	72°24'W	564
19978	PA-2003	40°32'N	75°95'W	≤60
20024	PA-2003	40°36'N	80°00'W	≤60
20036	PA-2003	42°09'N	80°02'W	≤60
20043	PA-2003	41°15'N	75°18'W	≤60
20059	VT-2003	44°05'N	73°20'W	1521

NY = New York, CT = Connecticut, PA = Pennsylvania, MD = Maryland, ME = Maine, MA = Massachusetts, NJ = New Jersey, VT = Vermont

Only five of the 19 birds marked in 2003 made molt migrations to northern Quebec (three from Pennsylvania, one from New York, and one from Vermont). Three traveled to the eastern coast of Hudson Bay (58°12'N, 76°60'W), one went to eastern James Bay (53°54'N, 79°00'W), and one moved to an interior location south of Ungava Bay (57°00'N, 74°36'W) (Figure 1). The 14 females that did not make a molt migration exhibited little movement during June through early November; movement of these geese was limited to within 60 km of the banding site. All of the birds that did not make a molt migration were from more coastal regions of the flyway (Figure 2).

Molt migrations in both 2001 and 2003 occurred in June. Marked geese that molt migrated (n = 12) were located in the U.S. as late as 30 May – 20 June. They arrived at terminal locations in northern Quebec (Fig-

ure 1) between 9 and 26 June. Fall migration of these molt migrants occurred primarily in September. Birds were located in northern Quebec as late as 28 August – 29 September. They arrived in southern Canada or the U.S. between 6 September and 3 October (Figure 3). There was no distinguishable difference in timing of molt and fall migrations between marked geese in 2001 and 2003. Molt migrations ranged in distance from 564 – 1941 km (Table 1).

Genetic analysis of the two groups of geese showed no evidence across loci of significant differences in microsatellite allele frequency ($F = 0.005$, $P > 0.05$). Likewise, analysis of variance results for mtDNA haplotype frequencies also revealed no evidence of significant differences between the two groups ($\Phi = 0.00$, $P > 0.40$). When analyses were extended to include reference samples from the two subarctic-nesting Canada Goose populations (AP and NAP), we observed differences in allele frequencies among all three populations for both microsatellite loci and mtDNA haplotype ($P < 0.05$ for both markers).

Discussion

Our results provide convincing evidence of the movement of some molting AFRP geese to the northern breeding ground of AP geese at a critical time during the spring population monitoring and summer prehunting season banding periods. Zicus (1981) and Lawrence et al. (1998), working with temperate-breeding Canada Geese in Wisconsin and Illinois, each reported 50-60% of their spring population departing on molt migrations. Mykut (2002) satellite-tracked female Canada Geese in Michigan, whose nests were destroyed, as in this study, late in incubation. He found 62% ($n = 37$) in 2000 and 73% ($n = 52$) in 2001 of these birds molt-migrating to James and Hudson Bays in northern Canada. The literature is replete with other reports of long distance molt migrations in temperate-nesting geese.

The propensity to molt migrate, observed in nest-failed females from rural New York and Pennsylvania, but not for birds nesting in more coastal areas of the flyway, prompted us to suspect a possible genetic difference resulting from regional differences in the origin of these birds. Blandin and Heusmann (1974) reported that geese breeding in eastern Massachusetts were of mixed racial stock, nonmigratory in nature, and the progeny of decoy birds released in the late 1930s. Morphometric measurements of these birds (Pottie and Heusmann 1979) indicated a probable mixing of several sub-species, in which *B. c. maxima* (Giant Canada Goose) predominated. In contrast, geese in rural New York and Pennsylvania are primarily large Canada Geese of the *B. c. maxima* and *B. c. moffitti* (Great Basin Canada Goose) stock introduced after the 1950s to areas previously devoid of breeding geese. These birds may be more similar to mid-continent temperate-nesting populations of restored or reintroduced giant Canada Geese. Molt migration in giant Canada Geese is considered a common behavior (Abraham et al. 1999). We were able to detect genetic differences of sufficient magnitude to discern the AFRP geese we sampled from subarctic-nesting populations of geese occurring in the flyway (AP and NAP), but we did not detect genetic differences between the two regional cohorts sampled within the AFRP.

Two factors favoring movement of waterfowl to remote regions to molt are the reduced risk to survival and greater food availability (Hohman et al. 1992; Baldassarre and Bolen 2006). In Canada Geese, successful breeders also are often behaviorally dominant over nonbreeders (Raveling 1970), which may influence movement of the nonbreeding segment away from nesting areas. However, in New Jersey, Nichols et al. (2004) estimated that only 22-31% of resident Canada Geese migrated out of the state to molt. They suggested that birds in and near urban-suburban dominated landscapes may have many suitable molting sites consisting of large expanses of lush, fertilized lawns interspersed with water bodies and few predators. The gathering of nonbreeders into larger flocks to molt on or near breeding areas may also lessen stress associated with behavioral interactions of adults with young. Lawrence et al. (1998) also noted that in more recent times, with greater emphasis on hunting of temperate-nesting geese to manage their numbers, birds leaving the sanctuary of local breeding areas are more likely to be harvested.

The coastal region of our study, from which molt migration did not occur (Connecticut, Massachusetts, Maryland, and New Jersey), contains ~21% ($N = 245351$) of the AFRP spring population estimate (United States Fish and Wildlife Service 2007*) in the U.S. Geese in New York, Pennsylvania, and Vermont make up ~45% ($N = 514181$) and the coastal states of Delaware and Virginia, where geese were not sampled as part of this study, comprise ~14% ($N = 163655$). If we assume that 50% of the geese in New York and Pennsylvania are molt migrant non-breeders or unsuccessful breeders (Zicus 1981; Lawrence et al. 1998), then the potential exists for a substantial movement of geese (≥250 000) to subarctic breeding areas in northern Canada. This number is further increased by temperate-nesting birds moving into subarctic regions from the Mississippi Flyway.

The population estimate for AP geese in northern Quebec, where we suspect most AFRP birds molt migrate to, is ~1.2 million (Harvey and Rodrique 2007*). However, the authors caution that differences in survey timing and the abundance of molt migrants can clearly introduce substantial variability in the total population estimate. Similar conflicts are reported by Abraham et al. (1999) for Southern James Bay Population Canada Geese in northern Ontario. Spring surveys of AP geese are timed to cover the mid to late incubation period; generally the last two weeks in June. Arrival of AFRP

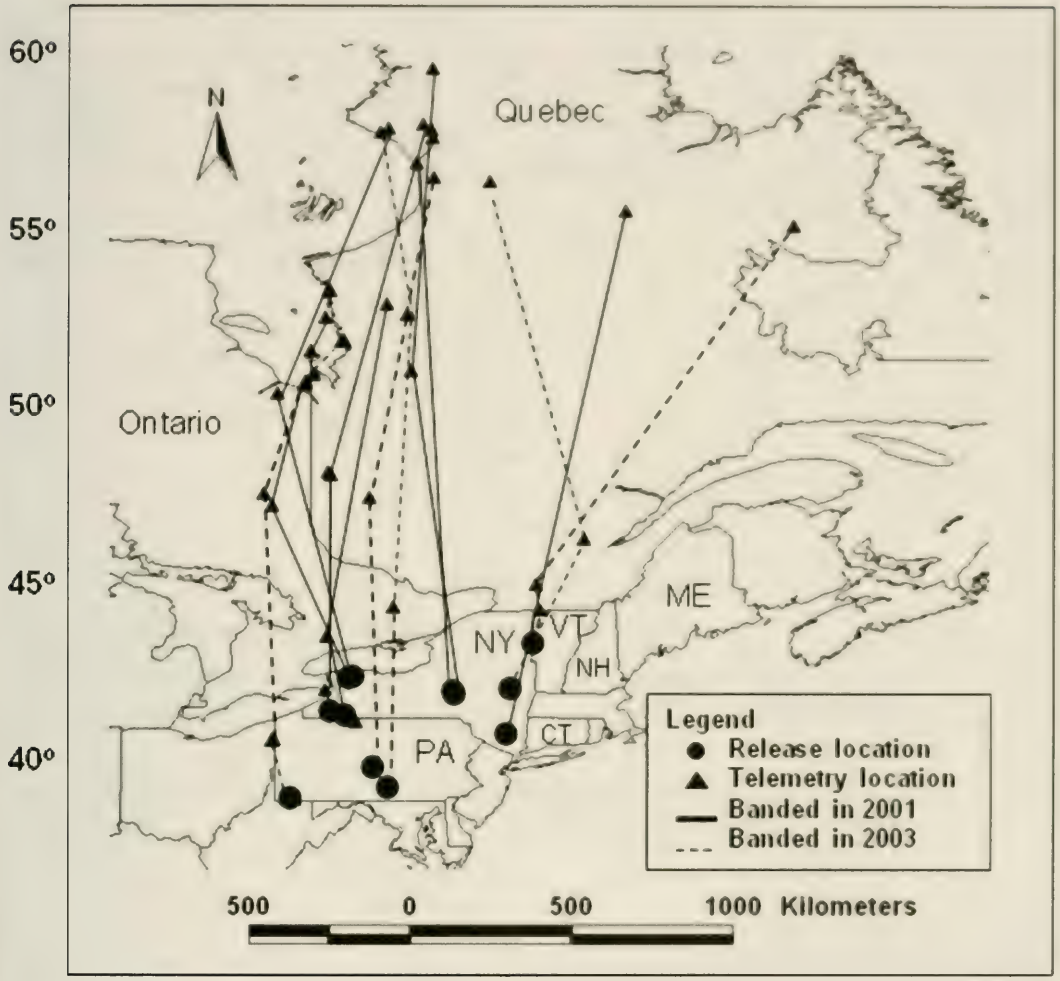

FIGURE 1. Locations of Atlantic Flyway Resident Population Canada Geese during spring molt migration in 2001 and 2003. Locations were identified using birds marked with satellite-tracked transmitters. Birds arrived at terminal molting areas in northern Quebec between 9 June and 16 June.

molt-migrants coincides very closely with the beginning of these surveys. Similarly, summer banding of AP geese, which usually takes place in late July – early August, also occurs when molt migrants are still on the AP breeding grounds. Given that molting large Canada Geese can require up to 40 days to obtain the 85% of primary feather development required to regain flight (Hanson 1965), geese arriving in mid-June have the potential still to be flightless when subarctic-breeding adults with young are being banded. This mixing of populations re-enforces the need to (1) monitor the status of subarctic-breeding populations using numbers of breeding pairs surveyed, rather than total counts involving groups of geese of unknown origin, and (2) band only flightless adults with young during the summer pre-season banding period to ensure a representative sample of subarctic-nesting populations of Canada Geese.

In the late 1980s, as an aid in the control of increasing numbers of temperate-nesting geese, the U.S. Fish and Wildlife Service endorsed the implementation of special hunting seasons in September and late-winter, when subarctic-nesting goose populations would be less likely affected (Heusmann et al. 1998). While effective in many rural areas, geese in urban and suburban environments often receive little exposure to hunter harvest (Smith et al. 1999). Efforts to control nuisance geese generally rely on non-lethal methods involving addling and oiling of eggs in nests (Christens et al. 1995) and harassment techniques to move birds from heavily used residential and industrial areas (Holevinski et al. 2007). Both methods provide only a moderate degree of relief, at best.

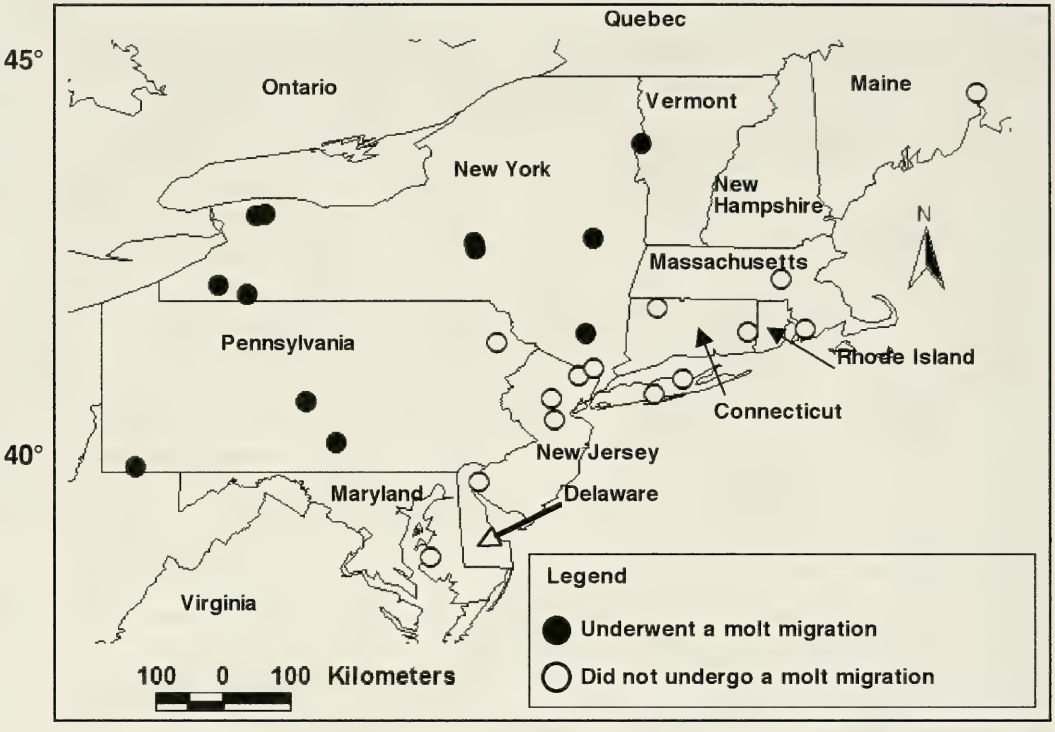

FIGURE 2. Banding locations of Atlantic Flyway Resident Population Canada Geese marked with satellite-tracked transmitters during May 2001 and 2003.

Many studies have demonstrated that altering survival of adult geese is much more effective in changing population size than altering recruitment rates (Trost et al. 1986; Schmutz et al. 1997). However, direct culling of molting birds continues to remain a socially unacceptable option for population control in many areas. One alternative, transplanting flightless adults with young from nuisance areas to rural areas prior to the fall hunting season, successfully reduced survival of adults in comparison to non-transported birds, but was both time consuming and costly (Holevinski et al. 2006). Inducing molt migration of adult breeding geese by destroying nests late in incubation, as demonstrated in this study, showed potential for both removal of birds from their breeding area during the spring and summer period and exposing them to hunting outside the region. However, our failure to demonstrate this in coastal areas, which have more prominent nuisance Canada goose issues, was problematic. We can only assume that the reason for this was attributed to the historical origin of captive-reared birds of mixed subspecies making up AFRP flocks in this part of the flyway and the availability of quality local molting habitat distinct from brood-rearing areas.

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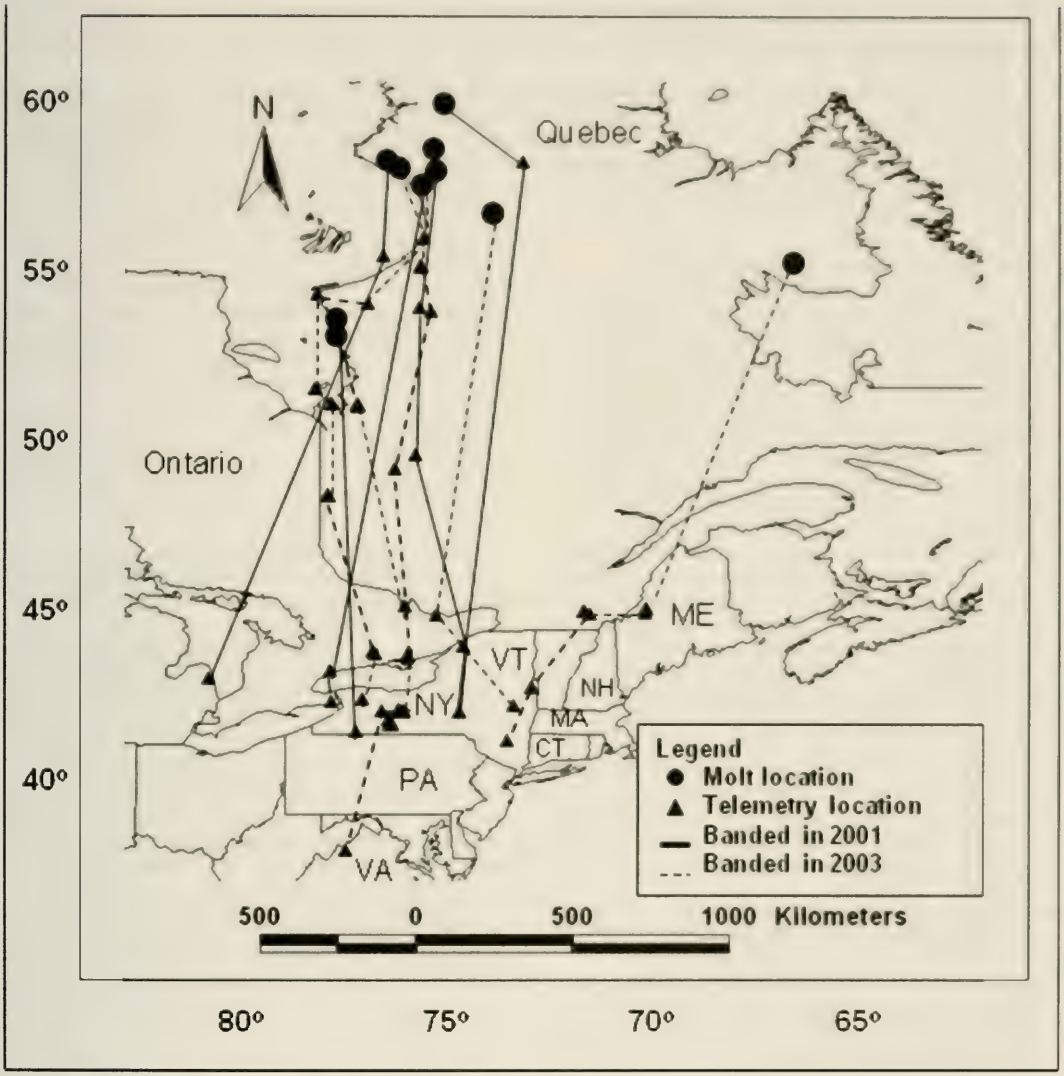

FIGURE 3. Locations of Atlantic Flyway Resident Population Canada Geese returning from molting locations in the fall 2001 and 2003. Locations were identified using birds marked with satellite-tracked transmitters. Birds initiated fall migration between 28 August and 29 September.

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Recovery of DNA from Footprints in the Snow

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The recovery of trace amounts of DNA has been demonstrated to be a reliable tool in conservation genetics and has become a key component of modern forensic casework. To date, genetic data have been successfully recovered from a variety of sources, including biological fluids, faeces, clothing, and even directly from fingerprints. However, to our knowledge and despite their widespread occurrence and clear potential as a source of DNA, genetic information has not previously been recovered directly from footprints. Here, we extract and amplify mitochondrial DNA from a snow footprint, <48-hours old, made by a Swedish Arctic Fox (*Alopex lagopus*). Our results demonstrate that it is possible to recover sufficient DNA from recent footprints to accurately type the source of the print, with implications for conservation biology and forensic science.

Key Words: Arctic Fox, *Alopex lagopus*, Red Fox, *Vulpes vulpes*, trace DNA, conservation biology, forensics.

Both conservation and forensic genetics rely on the ability to retrieve data from material containing only minute amounts of DNA. In forensic studies, key data are often generated from small amounts of biological tissue or liquids recovered from crime scenes (Bond 2007). Conservation geneticists are often interested in applying non-invasive sampling techniques in their research, many of which also target low copy-number biological sources such as hair or faeces (DeSalle and Amato 2004). Methods for recovering trace amounts of DNA have been fine-tuned over the last decade, resulting in the successful amplification of DNA from a variety of sources. For example, previous work has shown that it is possible to recover nuclear DNA from items of worn fabric, such as clothing and the insoles of shoes (Wickenheiser 2002; Bright and Petricevic 2004), and from other fabrics such as bedding (Petricevic, Bright, and Cockerton 2006). Hair shafts and faeces (Kohn and Wayne 1997) from humans, animals, and even ancient specimens (e.g., Higuchi et al. 1988; Gilbert et al. 2004; Pfeiffer et al. 2004; McNevin et al. 2005), fingernails and fingernail scrapings (e.g., Oz and Zamir 2000), and latent fingerprints (e.g., van Oorschot and Jones 1997; Alessandrini et al. 2003; Balogh et al. 2003) have also been shown to be good sources of both mitochondrial DNA (mtDNA) and nuclear DNA.

It is well known that DNA survival is affected by ambient temperature, with the greatest probability of survival occurring in locations with constant low temperatures (Smith et al. 2003). It is therefore conceivable that should biological material be deposited in ice or snow this frozen environment would provide ideal conditions for DNA survival. Potential sources of DNA in ice or snow include shed cells, hair, and biological fluids. However, previous attempts to isolate DNA from randomly selected patches of ice and snow have shown that DNA is rare in the general environment (Hansen and Willerslev 2002). Nonetheless, if it were possible to identify patches in which DNA is concentrated, the combination of cold preservation and the purity of the sample should make these patches an excellent source of genetic information.

The ability to amplify DNA from fingerprints has shown that a few shed skin cells are sufficient for genetic typing. Footprints made by people or animals should therefore be equally viable sources of DNA; however, the nature of the location of footprints (on the ground, mixed with myriad other genetic data) has made this hypothesis difficult to test. Footprints made in snow, however, are unlikely to be contaminated by other sources of DNA or chemical inhibitors. Here, we investigate whether it is possible to recover DNA directly from animal footprints made in snow, and discuss the potential of such an approach for forensic science and conservation biology.

Materials and Methods

Six samples from fresh (<48h old) fox tracks were collected in Jämtland County, Sweden, during the winter in 2006. Samples were taken from different tracks, so as to minimise the risk of sampling the same individual twice. Each imprint was carefully excavated from the snow using sterile equipment and put into 50 ml Falcon tubes. Three additional samples were taken from undisturbed snow, for use as negative controls. Due to the possibility of low DNA yields from footprints, and ensuing risk of contamination, the DNA extractions were done in a dedicated ancient DNA

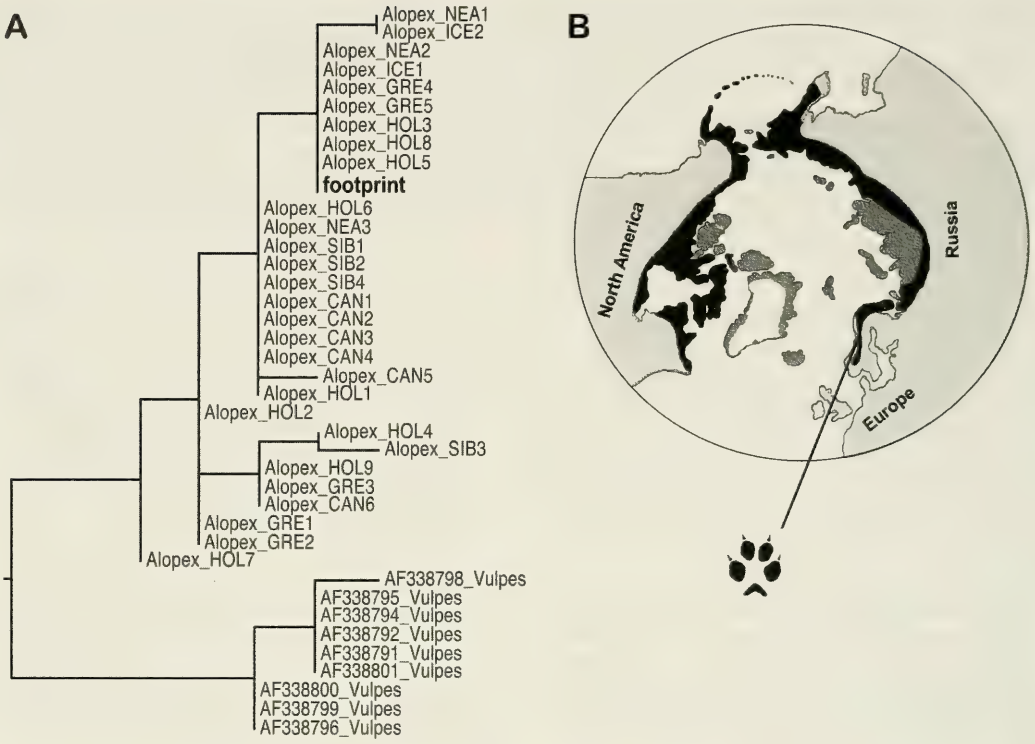

FIGURE 1. (A) Maximum liklihood tree describing the relationships between mitochondrial DNA sequences from Arctic Foxes, Red Foxes, and that recovered from the footprint in central Sweden. Details of the phylogenetic analysis and statistical support are given in the text. (B) Map showing the Holarctic distribution of the two species of fox. Lighter and dark grey shading indicates the distribution of the Red Fox and Arctic Fox, respectively, and black shading indicates where the two ranges overlap. The line indicates the location in Sweden from which the footprints were recovered.

facility in Madrid, Spain. The samples were concentrated using 15 ml Amicon filters (Millipore Massachusetts, USA) and extracted from the resulting filtrate following the protocol by Yang et al. (1998), as modified by Svensson et al. (2007). An approximately 150 base pair (bp) fragment of the mitochondrial control region was amplified using primers Pex3F and H3R (Dalén et al. 2007). Resulting PCR products were sequenced using the Big Dye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, California, USA) and analysed on an Applied Biosystems 3730xl sequencer following the manufacturer's instructions.

Previously published Arctic Fox (*Alopex lagopus*) and Red Fox (*Vulpes vulpes*) mitochondrial DNA sequences covering the length of the 150-bp amplifid fragment were collected from GenBank (accession numbers AF338791-AF338792, AF338794-AF338796, AF338 798-AF338801, AY321120-AY321148) and aligned by eye. A Maximum Likelihood (ML) phylogenetic analysis was performed using the program PAUP v4.10b (Swofford 1999). An HKY model of nucleotide substitution was assumed, so as to allow for different rates of transitions and transversions along the sequences. Starting trees were generated by neighbor-joining (NJ), from which subsitution parameters were estimated and fixed. Heuristic searches were then performed using the estimated substitution parameters and SPR branch swapping. Substitution parameters were then re-estimated from the most likely trees and the analysis was repeated. Figure 1 shows the resulting ML tree describing the relationship of the sequence amplified from the footprint with Arctic and Red foxes. The two clades are separated by bootstrap (100 full heuristic runs, with starting trees generated by NJ and NNI branch swapping) support values of 96%.

Results

Mitochondrial DNA was recovered from one of the six footprints from which snow was collected. While it has been shown recently that DNA can be recovered from faecal and hair samples collected along animal

tracks (Ulizio et al. 2006), this is the first report of DNA being recovered directly from the tracks themselves. Identification of species from tracks presents an important resource for conservation and management of rare species. In this case, both Arctic and Red foxes inhabit the Swedish mountain tundra, and the footprint could thus have derived from either of the two species. However, the resulting mtDNA sequence showed that the footprint originated from an Arctic Fox (Figure 1) and was identical to one of the three mtDNA haplotypes that exist today in Sweden (Dalén et al. 2005).

Discussion

While the overall success of this initial study was small, it is worthwhile to note that, in this case, only one footprint was sampled from each track. If this method were to be applied in a forensic or conservation genetics context, it would be reasonable to sample several footprints from the same track, significantly increasing the potential for DNA recovery. While this approach would increase the volume of snow or other substrate from which the biological material must be recovered, modern filtration devices such as those employed in this study make it feasible to concentrate large volumes in relatively little time.

The ability to recover DNA from footprints has implications for many areas of research that rely on the ability to amplify low copy number DNA. For example, DNA from footprints could be used to identify individual carnivores that prey on livestock, or to link animal prints found at a crime scene to a specific individual. In conservation genetics, this method makes it feasible to follow individual movements across a landscape, and to directly establish the dimensions of individual home ranges. Perhaps most importantly, the amplification of DNA from footprints could serve as an additional source of non-invasive sampling, complementing conventional materials such as faeces (Höss et al. 1992), hair (Taberlet et al. 1993) and urine (Valiere and Taberlet 2000), and potentially avoiding many of the problems with inhibition that are associated with these sources of DNA.

Acknowledgments

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Notes

A River Otter's, *Lontra canadensis*, Capture of a Double-crested Cormorant, *Phalacrocorax auritus*, in British Columbia's Gulf Island Waters

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Price, Michael H. H., and Clare E. Aries. 2007. A River Otter's, *Lontra canadensis*, capture of a Double-crested Cormorant *Phalacrocorax auritus*, in British Columbia's Gulf Island Waters. Canadian Field-Naturalist 121(3): 325-326.

Direct and apparent predation events by River Otters (*Lontra canadensis*) on birds have been recorded on marine islands and freshwater lakes. We add to this the first known observation of a River Otter capturing a marine bird on the ocean.

Key Words: River Otter, *Lontra canadensis*, diet, birds, foraging, conservation, coastal, islands, British Columbia

The River Otter (*Lontra canadensis*) is a largely piscivorous carnivore inhabiting riparian areas, coastal shorelines, and archipelagos of North America (Cowan and Guiguet 1965). Their diets have been well described along inland river systems and lakes (Sheldon and Toll 1964; Knudsen and Hale 1968; Reid et al. 1994), yet little is known about their ecology in marine communities. Nevertheless, fishes are their primary food in all habitats (Lagler and Ostenson 1942; Stenson et al. 1984; Bowyer et al. 1994). Birds are considered rare and sporadic food items (Toweill 1974; Stenson et al. 1984).

Early reports of bird remains in the stomachs or faeces of River Otters suggested that they scavenged carcasses (Lagler and Ostenson 1942; Sheldon and Toll 1964). Years later, it was postulated that River Otters probably consume wounded or incidentally killed birds hunted by humans (Toweill 1974). In coastal British Columbia, Washington, and Alaska, however, researchers have recently described predation events by River Otters on nesting marine birds (Hayward et al. 1975; Foottit and Butler 1977; Verbeek and Morgan 1978; Quinlan 1983; Speich and Pitman 1984; Duffy 1995). We herein describe a River Otter's successful aquatic capture of a Double-crested Cormorant (*Phalacrocorax auritus*) in marine waters.

At approximately 1130 hours on 18 February 2005, a family of four River Otters [one adult – three juveniles] swam in an unnamed cove adjacent to Swartz Bay, Vancouver Island (48°42'N, 123°25'W). The sky was overcast, and the sea and winds were calm. At this time, we also observed a mixed raft of approximately 120 Double-crested and Pelagic (*P. pelagicus*) cormorants and Pacific Loons (*Gavia pacifica*) situated 400 meters from the River Otters to the north. The birds drifted east with the current, roughly 100 meters south of Piers Island. They consistently dived and surfaced, presumably feeding on small fishes [Pacific Sandlance (*Ammodytes hexapterus*) or Pacific Herring (*Clupea pallasii*)].

The four River Otters swam directly towards the raft with their heads above water. When within 50 meters, all Otters dived in succession; apparently the foraging birds failed to detect their approach, as they continued to dive and surface. Less than two minutes later, a lone River Otter began swimming south to the unnamed cove with its head above water, towing a large object in its mouth. It dived, and re-surfaced less than 3 meters from our viewing platform with a gasping Double-crested Cormorant held by its throat. The River Otter then swam beneath a shoreline cabin, directly adjacent to a known den-site, and presumably fed upon its prey. We failed to observe the juvenile River Otters from that point on, and saw no evidence of them joining the adult to consume the cormorant. We also saw no physical evidence [i.e., carcass or feathers] after the event.

Observations of River Otters preying on birds are rare and almost exclusively observed on land or freshwater. For example, River Otters have ambushed nesting Glaucous-winged Gulls (*Larus glaucescens*), Aleutian Terns (*Sterna aleutica*) (Hayward et al. 1975; Foottit and Butler 1977; Verbeek and Morgan 1978; Duffy 1995), and Slavonian Grebes (*Podiceps auritus*) (Perkins et al. 2005), and preyed on incubating Storm-petrels [(*Oceanodroma furcata* and *O. leucorhoa*)] by digging them out of nesting burrows (Quinlan 1983). River Otters have also been observed preying on moulting American Widgeon (*Anas americana*) and Green-

winged Teal (*A. crecca*) on a freshwater lake in Alberta (Reid et al. 1994), and a Common Gallinule (*Gallinula chloropus*) on a slurry pond in Florida (Meyerriecks 1963). To our knowledge, this is the first observation of a River Otter preying on a bird on the ocean.

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Winter Occurrences of Ivory Gulls, *Pagophila eburnea*, in Inland Labrador

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Chubbs, Tony E., and Frank R. Phillips. 2007. Winter occurrences of Ivory Gulls, *Pagophila eburnea*, in inland Labrador. Canadian Field-Naturalist 121(3): 327-328.

Ivory Gulls were observed during winter on three occasions up to 325 km inland from open coastal water, feeding on Caribou carcasses in inland Labrador. Other recent observations in central Labrador are also noted.

Key Words: Ivory Gulls, *Pagophila eburnea*, range, distribution, Labrador.

The Ivory Gull (*Pagophila eburnea*) is a plump, medium-sized gull (40-43 cm long; 108-120 cm wing span), about 10% larger and longer-winged than the Black-legged Kittiwake (*Rissa tridactyla*), with sexes alike and plumage entirely white in adults (Haney and MacDonald 1995). Ivory Gulls are High Arctic birds that have a circumpolar distribution ranging across northern Canada, Greenland, and arctic western Europe (Haney and MacDonald 1995; Gilchrist et al. 2005). The known Canadian population breeds in remote locations on Ellesmere, Devon, Seymour, northwestern Baffin and Perley islands, Nunavut (Todd 1963; Haney and MacDonald 1995; Thomas and MacDonald 1987; Stenhouse et al. 2004; Gilchrist and Mallory 2005).

Ivory Gulls, locally referred to as "Ice Partridges" (Peters and Burleigh 1951) or "Ice-Gulls" (Tuck 1971), are uncommon winter visitors in coastal Labrador and northern Newfoundland (Todd 1963). They are rarely found far from drifting pack ice offshore in winter near the southern pack ice between Canada and Greenland (Haney and MacDonald 1995; Stenhouse et al. 2004). Ivory Gulls appear along the northeast coast of Newfoundland and Labrador in December, usually well offshore, but they are most abundant in March when they concentrate on Harp Seal (*Pagophilus groenlandicus*) whelping areas in the pack Ice (Tuck 1967, 1971). Historic inshore observations of Ivory Gulls in Newfoundland and Labrador have occurred along the northeast coast of insular Newfoundland between December and March (Tuck 1971) with fewer records along the Labrador coast (Todd 1963). The largest numbers of Ivory Gulls recently recorded in our region have been in southeastern Labrador and northern Newfoundland following strong northeast gales (P. Linegar, personal communication). Peters and Burleigh (1951) indicated that there were a number of reports of the "Ice Partridge" from interior localities in Newfoundland and one specifically from Badger, but those sightings were not confirmed. Several adult Ivory Gulls have been banded at sea off Cape Chidley, Labrador (Thomas and MacDonald 1987), and a band was recovered in 1940 at Port Hope Simpson, Labrador (52°30'N, 56°10'W) that was banded in Franz-Joseph Archipelago (North of Russia) six years previously (Tuck 1967, 1971). Occasionally, there have been anecdotal observations of Ivory Gulls at North West River, Labrador, during winter, where the water remains open (P. Linegar personal communication). A recent observation at North West River was of a single immature Ivory Gull on 16 March 2006 (J. Thomas, Department of Natural Resources, personal communication). An adult and an immature Ivory Gull were also observed on 10 and 17 February 2007 at Dry Island (53°42.00'N, 59°59.50'W) near North West River (S. Russell, personal communication).

The Ivory Gull is designated as Endangered in Newfoundland and Labrador under the province's Endangered Species Act (NL ESA Regulation 57/2, 2002*) and in Canada under the federal Species at Risk Act (SARA Schedule 1) (COSEWIC, April 2006*). Recent aerial breeding colony surveys in the eastern Canadian Arctic revealed an 85% decline in numbers of breeding Ivory Gulls since the early 1980s (Gilchrist and Mallory 2005; Gilchrist et al. 2005).

Our observations were made while travelling along the Trans-Labrador Highway between Happy Valley-Goose Bay and Churchill Falls in central Labrador. This area lies within the Lake Melville-High Boreal Forest ecoregion and is dominated by Black Spruce (*Picea mariana*) with lesser amounts of Trembling Aspen (*Populus tremuloides*), White Birch (*Betula papyrifera*), Balsam Fir (*Abies balsamea*) and White Spruce (*P. glauca*) in river valleys (Meades 1990*). This region has the most moderate climate in Labrador with mean average daily temperatures ranging from −14 to −18°C in February and +13°C in July. Average annual precipitation is 1100 mm with an average snowfall accumulation of 4 m (Meades 1990*).

On 8 March 2003, F. R. Phillips and F. Taylor observed an adult Ivory Gull along the Trans-Labrador Highway approximately 5 km west of Metchin River (53°26'N, 63°18'W). The Ivory Gull was feeding on Caribou (*Rangifer tarandus*) remains left by hunters of

the migratory George River Caribou herd. The observation was located approximately 325 km west of the nearest permanently open coastal water at Rigolet (54°11'N, 58°27'W), and nearly 400 km inland from the edge of the coastal ice pack.

On 23 March 2006 we observed an adult Ivory Gull near the same location as the sighting recorded in 2003. This Ivory Gull was at a campsite adjacent to the Trans-Labrador Highway, 10 km west of Metchin River (53°26'N, 63°21'W) where approximately 15 Innu hunters had recently harvested 58 caribou. The Caribou carcasses, laid on the snow, were intact with the hide, head and legs attached with only the entrails removed. The Ivory Gull was feeding on the exposed flesh and offal of the Caribou adjacent to the road. The hunters indicated that the Ivory Gull had been present and feeding on scraps of Caribou meat for several days, alternating feeding sites between the road and the Churchill River, where the animals were harvested. On 26 March 2006, F. R. P. returned to the Innu camp but did not observe the gull. The hunters indicated that they had last observed the Ivory Gull on 24 March 2006.

On the morning of 26 March 2006, T. E. C. observed an adult Ivory Gull adjacent to his home in the community of Happy Valley-Goose Bay (53°18.92'N, 60°22.95'W) feeding on scraps of Caribou meat from a hunt the previous week. This location is approximately 195 km east of our sighting at Metchin River, three days earlier, and was possibly the same bird. We placed several large pieces of Caribou meat on the snow to feed the Ivory Gull and to encourage it to stay for further observation and photographs. At approximately 1500 hrs on 27 March 2006, an adult Glaucous Gull (*Larus hyperboreus*) joined the Ivory Gull and both fed on the Caribou meat. Both Gulls appeared to have departed on the evening of 27 March 2006 and were not observed again.

To our knowledge, our sightings are the first confirmed inland observations of Ivory Gulls recorded for insular Newfoundland or Labrador. These observations of Ivory Gulls in central Labrador may have been influenced by the recent southern extension of the winter range of the George River Caribou herd, which has occurred during the last two decades (Chubbs and Phillips 2005). Caribou from the George River herd have been recorded as far south as 52°10'N in central regions and may have facilitated the inland range expansion of other scavengers such as Coyotes (*Canis latrans*) into Labrador (Chubbs and Phillips 2005). With the Canadian Arctic breeding population of Ivory Gulls possibly in peril, and little information on their life history outside their breeding grounds, our inland observations add to the knowledge of this species' feeding habits and migration stopovers in Labrador that may provide some insight into the recent decline of this species in Canada or aid in the recovery of the population.

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Northern Goshawk, *Accipiter gentilis*, Exploits a Beagle Hound, *Canis familiaris*, as a "Beater" to Catch a Snowshoe Hare, *Lepus americanus*

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Neville, John T. 2007. Northern Goshawk, *Accipiter gentilis*, exploits a beagle hound, *Canis familiaris*, as a "beater" to catch a Snowshoe Hare, *Lepus americanus*. Canadian Field Naturalist 121(3): 329-330.

During a winter Snowshoe Hare (*Lepus americanus*) hunt with a beagle hound (*Canis familiaris*), I observed an adult Northern Goshawk (*Accipiter gentilis*) exploiting the running, barking hound as a "beater" and use strategic locations for attacks. The hawk made three attacks on a hare being pursued by the hound, and subsequently caught and killed it. To my knowledge, this report represents the first record of a Northern Goshawk using this behavior to capture prey.

Key Words: Northern Goshawk, *Accipiter gentilis*, Snowshoe Hare, *Lepus americanus*, beagle, *Canis familiaris*, beater, hunting, Newfoundland.

In eastern boreal forests, Spruce Grouse (*Dendragapus canadensis*), Ruffed Grouse (*Bonasa umbellus*), Red Squirrel (*Tamiasciurus hudsonicus*), and Snowshoe Hare (*Lepus americanus*) comprise major components of Northern Goshawk (*Accipiter gentilis*) diets (Johnsgard 1990: pages 177-182). Goshawks winter throughout their breeding range when these prey species are abundant; however Goshawks in the northern parts of their range may move further south when populations of Ruffed Grouse and especially Snowshoe Hares crash (Palmer 1988; Johnsgard 1990). In my described observation area, hares were abundant, squirrel numbers low, and both grouse species, as well as alternative prey items, very low in abundance (personal observation).

The observations described occurred in western Newfoundland (49°05'N, 57°31'W) on 4 December 2004. The area consists of approximately 70% mixed Balsam Fir (*Abies balsamea*) Black Spruce (*Picea marina*) in various-aged stands and 30% forest openings consisting of small bogs, blowdowns and alder (*Alnus* sp.) swales. Approximately 10 cm of snow had accumulated on bare ground over the previous 10 days.

During a Snowshoe Hare hunt with a beagle hound I observed unusual hunting behavior by an adult female Northern Goshawk (sex and age judged by size and plumage; Palmer 1988). The hawk exploited the running, barking dog as a "beater", and positioned itself into opportunistic attack locations where prey would likely be flushed ahead of the oncoming hound. The hawk regularly repositioned itself and selected tree-top perches (Kenward 1982) ahead of the dog in locations where it could scan the snow surface. Over approximately 20 minutes I witnessed three attacks on a hare actively pursued by my hound, the last resulting in the hare being caught and killed. With the aid of binoculars, I was able to observe the hawk's head and its fixation on snow surfaces ahead of the barking hound. I noted the hawk relocate itself 10 times during the described hunt.

The first attack occurred after the hawk had positioned itself on a tree-top perch above a 10 m-wide alder swale which offered enhanced viewing of the snow surface from above. As the barking hound progressed towards the perched hawk, the hare suddenly appeared in the alder swale and the hawk swooped down and attempted to catch it. However, dense alders hindered the bird, and the hare evaded capture. A second capture attempt occurred in similar fashion as the hare ran along the edge of a small bog. The hare re-entered dense cover before the attacking hawk approached to within about 8 m. Both of these capture attempts occurred approximately 40 m from my location. The final attack occurred roughly 60 m from my location in a 10 m by 15 m opening in the canopy. I did not see the attack but heard the hare emit a distress cry about 50 m ahead of the barking dog indicating that it had been caught. After approximately 1 minute the hound reached the attack location where its steady barking changed to intense growling indicating that the dog was then in the presence of the hawk. I advanced toward the kill site when from a distance of less than 5 m an adult Goshawk flew off the snow surface carrying an intact limp hare in its talons. The bird struggled in flight due to the mass of the hare and it was assumed that my sudden appearance had caused the bird to flee with its prey. The snow revealed indications of the attack: hare tracks, wing tip impressions, hare fur, blood and an obvious struggle site while backtracking verified that it was the hare under pursuit of my hound. Due to the quality of trailing by the hound, the hare's running ability and the apparent normal size of the hare, it is believed that it was in good condition. In addition, hares that I harvested that day and on following hunts in the same area were in excellent condition. These scenes occurred in fairly dense spruce/fir forest with the likelihood that additional attacks, without my detection, had occurred.

On 11 and 18 December 2004 during hare hunts in the described area, an adult Goshawk was observed

several times in the vicinity of the barking hound which was trailing a hare; one unsuccessful attack on a hare trailed by the hound was noted. At no time during these events did I observe the hawk attempt to strike the dog. It was also noted that Goshawks had walked along and followed hare trails on the snow surface (also cited in Palmer 1988), indicating a strong reliance upon hares in that area.

The effectiveness of exploiting beaters has been demonstrated in several species. Cattle Egrets (*Bubulcus ibis*) exploit cattle as "beaters" to flush insects and small mammals (Welty and Baptista 1988: page 422), and by doing so were more efficient than when foraging alone (Dinsmore 1973; Grubb 1976). Both Merlins (*Falco columbarius*) and Peregrine Falcons (*Falco peregrinus*) have followed Northern Harriers (*Circus cyaneus*) (Dickson 1984 in Palmer 1988); and Rough-legged Hawks (*Buteo lagopus*) have been observed following Arctic Fox (*Alopex lagopus*) to catch disturbed voles and lemmings (Welty and Baptista 1988). Reynolds (1965) suggested that beater associations may be regular, as with the Cattle Egret, or may represent an individual capacity to take advantage of a favorable situation. The latter better describes my observations, which likely originated out of curiosity as the Goshawk investigated the dog's barking and was rewarded with prey capture opportunities. As far as I can determine, this is the first report of a Northern Goshawk or any *Accipiter* sp. utilizing "beating" behavior to aid in prey capture.

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Giant Beaver, *Castoroides ohioensis*, Remains in Canada and an Overlooked Report from Ontario

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Harington, C. Richard. 2007. Giant Beaver, *Castoroides ohioensis*, remains in Canada and an overlooked report from Ontario. Canadian Field-Naturalist 121(3): 330-333.

The Giant Beaver (*Castoroides ohioensis*) was the largest ice age rodent in North America, reaching about the size of a Black Bear (*Ursus americanus*). In Canada, fossils of this species are commonly found in the Old Crow Basin, Yukon, and single specimens are known from Toronto, Ontario and Indian Island, New Brunswick. A hitherto overlooked 1891 record of a Giant Beaver skull from near Highgate, Ontario is the earliest for Canada.

Key Words: Giant Beaver, *Castoroides ohioensis*, Pleistocene, Highgate, Ontario, earliest Canadian record, paleoenvironment.

The Giant Beaver (*Castoroides ohioensis*) was the largest rodent in North America during the ice age (Quaternary – approximately the last 2 million years) (Kurtén and Anderson 1980). The great morphological similarity between Giant Beaver and modern Beaver (*Castor canadensis*) leaves no doubt that the two animals were much alike in appearance and were adapted to similar surroundings (Figure 1).

But there was one remarkable difference – size! Adults reached a length of nearly 2.5 m, the size of a Black Bear (*Ursus americanus*), and may have weighed as much as 200 kg (compared to a 1 m-long modern Beaver weighing about 30 kg) (Kurtén and Anderson 1980). However, Reynolds (2002), treating statistically a comprehensive sample, estimates Giant Beavers had a body mass of only 60 to 100 kg while assuming a length of 1.5 m [this ignores the nearly 2.5 m length of the skeleton displayed in Chicago's Field Museum of Natural History and the 2.2 m length for the Earlham College skeleton, which represents an immature individual (Barbour 1931, Figure 109)]. Using a regression she established for all rodents, Hopkins (2008) calculated a mass of 67 kg for *Castoroides*, which corresponds to Reynolds' estimate. Average weights of adult female Black Bears range from 40 to 70 kg and for adult males from 60 to 140 kg with body lengths of 1 to 2 m

FIGURE 1. Locations of Giant Beaver (*Castoroides ohioensis*) fossil sites in Canada: 1. Old Crow Basin, Yukon Territory; 2. Highgate, Ontario; 3. Toronto, Ontario; 4. Indian Island, New Brunswick. Insert shows two Giant Beavers (with fox for scale) in the foreground and Woolly Mammoths (*Mammuthus primigenius*) in the background. Reduced black and white image of a painting by George Teichmann (C.R. Harington and N. Rybczynski, scientific advisors).

(Pelton 1982), so Reynolds' estimate is still within the range for Black Bears. Other differences include a relatively narrow tail, cheek teeth with S-shaped enamel patterns on the grinding surfaces, and cutting teeth (incisors) about 15 cm long with prominently ridged outer surfaces (Harington 1996).

A primitive beaver (smaller than the modern beaver) called *Dipoides* that occupied Eurasia and North America during the late Tertiary (some 5 million years ago – indeed members of this genus occupied beaver ponds in the vicinity of Strathcona Fiord, Ellesmere Island, about 4 million years ago, Tedford and Harington (2003), and the Hand Hills, Alberta perhaps even earlier (Owen and Burns 2006) evidently gave rise to *Procastoroides*, a large beaver about two-thirds the size of the Giant Beaver. That beaver probably evolved into the Giant Beaver some 3 million years ago.

Castoroides ranged from Florida to the Yukon and from New Brunswick to Nebraska, but it has not been found outside of North America. Giant Beavers seem to have flourished in the region south of the Great Lakes toward the close of the last glaciation, about 10 000 years ago, and became extinct about that time (Harington 1996).

In Canada, Giant Beaver fossils have been found in great abundance in the Old Crow Basin of the northern Yukon (Harington 1977, 1978), and a single incisor was collected from the Don Formation in Toronto (Coleman 1933; Harington 1978) – fossils from both places probably extending back to at least last (Sangamonian) interglacial time some 130 000 years ago.

An isolated Giant Beaver incisor tooth was recovered from Indian Island, New Brunswick, near the mouth of the Bay of Fundy. It may have been deposited on a storm beach from near-shore deposits (Miller et al. 2000) (Figure 1).

It has recently come to my attention (personal communication, P. F. Karrow 2006) that a much earlier report from near Highgate, Ontario (approximately 42°30'N, 81°49'W) had been overlooked (e.g. Hay 1923; Harington 1996, 2003). J. H. Panton (Professor of Natural History and Geology, Ontario Agricultural College, Guelph, Ontario) on page 4 of an 1891 booklet titled *The Mastodon and Mammoth in Ontario*..., noted: "Associated with the remains of the [Highgate] Mastodon, a skull was found which the writer has identified to be that of an animal allied to the beaver, but this animal must have been fully six feet [about 2 m] in length, instead of two or three [about 0.61 or 0.91 m] like the Beaver of the present. One of its gnawing [incisor] teeth in the lower jaw is eight inches [20.3 cm]." I think that this description is sufficient to provide a veritable record of the Giant Beaver. Presumably this report was overlooked because of the relative rarity of Panton's (1891) published report – the only original copy known to me is in the rare book room of the Dufferin County Museum at Guelph, and because the specimen has not appeared in a major public collection. Unfortunately, I have yet to track down the actual specimen. It is not with the remains of the Highgate Mastodon (personal communication, J. Hoganson 2006).

The Highgate report is the earliest from Canada. The first recorded Giant Beaver remains were found in a peat swamp near Nashport, Ohio, and were described, but not named, by S.P. Hildreth (1837). The geologist J. W. Foster called the specimen *Castoroides ohioensis* in a publication a year later (Cahn 1932).

Giant Beavers, being well-adapted to swimming, seem to have preferred lakes and ponds bordered by swamps as their habitat because their remains have been found in ancient swamp deposits so often (Harington 1996). American Mastodons (*Mammut americanum*) evidently occupied similar habitat in open spruce forests. Indeed, at Boney Spring, Missouri, eight mastodon cheek teeth show tooth marks probably made by the lower incisors of *Castoroides* (Saunders 1977). It is worth noting that pollen analysis of sediment recovered from a hole in the sternum of the Highgate Mastodon (with which the Giant Beaver skull was associated) indicate that both mastodon and Giant Beaver occupied a boreal forest dominated by spruce probably between about 12 000 and 10 300 years ago (Hoganson 2006). Presumably this pollen analysis was carried out by McAndrews (1994, page 183) who indicates that his "recent analysis of mud" from the Highgate Mastodon shows that it belongs to pollen subzone 1b, which in his Figure 10.2 dates between about 11 800 and 10 000 BP [radiocarbon years before present (taken as 1950)].

Acknowledgments

I am indebted to the vigilance of my colleague Paul F. Karrow for noting Panton's (1891) record of the Giant Beaver skull from the vicinity of Highgate, Ontario, and thank John Hoganson for searching for the Highgate Giant Beaver skull in collections of the North Dakota Heritage Centre, Bismarck, where the Highgate Mastodon is kept. I thank two anonymous reviewers for valuable comments that helped to improve this paper.

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A Late Born White-tailed Deer, *Odocoileus virginianus*, Fawn in Southcentral Wisconsin

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Jacques, Christopher N., William E. Ishmael, Timothy R. Van Deelen, and Robert E. Rolley. 2007. A late born White-tailed Deer, *Odocoileus virginianus*, fawn in southcentral Wisconsin. Canadian Field-Naturalist 121(3): 333-335.

Published reports of peak breeding and parturition dates for White-tailed Deer (*Odocoileus virginianus*) indicate that deer in northern regions typically breed during November and give birth during late May and early June. However, we report a late born White-tailed Deer fawn killed by a vehicle between 12-13 March 2007 in south central Wisconsin. Morphology measurements and body weight indicated the individual was 63-76 days old, was born between 26 December 2006 and 8 January 2007, and was conceived between 14-27 June 2006. To our knowledge, this observation represents the latest documented breeding activity in northern deer populations.

Key Words: White-tailed Deer, *Odocoileus virginianus*, parturition, breeding, conception, Wisconsin.

Seasonally polyestrous breeding activities of northern White-tailed Deer (*Odocoileus virginianus*) are clearly synchronized by photoperiod (Verme and Ullrey 1984; Verme et al. 1987). However, timing of peak breeding activities and parturition can be affected by nutrition and deer herd demographics (Demarais et al. 2000). Low quality nutrition can prolong breeding and fawning activities, while high quality nutrition can shift peak breeding and fawning periods to earlier dates (Verme and Ullrey 1984).

Breeding dates vary throughout the range of the White-tailed Deer and may occur throughout the year in Central America or within short (2-3 weeks) time periods in northern deer populations (Dahlberg and Guettinger 1956; Moore and White 1971; Verme 1977; Clark 1981; Webb and Nellis 1981; Ozoga and Verme 1984). Similarly, gestation for deer varies from 196 to 213 days (Cheatum and Morton 1946; Haugen and Davenport 1950; Verme 1965, 1969), with peak parturition occurring in late May to early June in most northern deer populations (Verme et al. 1987; Brinkman 2003; Burris 2005).

Although rarely documented, occurrences of late breeding activity have been reported in northern deer populations. Throughout southcentral and northern Minnesota, previous investigations have reported conception dates in captive and free-ranging deer populations between 3 March and 9 April (Erickson 1952; Kerr and Peterson 1988; DePerno and Anderson 2000). However, we were unable to find documentation in the scientific literature of breeding activity occurring during June in northern deer populations. Our purpose was to report an occurrence of a late-born fawn and subsequent evidence of late breeding activity by White-tailed Deer in southcentral Wisconsin.

On 14 March 2007 a vehicle-killed spotted male fawn was retrieved from State Highway 23 near the village of Plain in Franklin Township, Sauk County, Wisconsin (43°16'30"N, 90°03'00"W). Because Highway 23 is frequently traveled by WEI, we are certain this fawn was killed between 12-13 March 2007. At the time of carcass retrieval, recorded body weight was 17.7 kg (39.2 lbs); however, the hindquarters were slightly scavenged. Because the amount of tissue removed by scavengers was minimal (≤ 1 kg), the estimated body weight of this fawn was 18.7 kg (41 lbs).

Normally, fawns from well-fed adult females average 3-4 kg (6.6 to 8.8 lbs) at birth (Verme and Ullrey 1984; Nelson and Woolf 1985; Verme 1989) and typically gain 0.20 to 0.24 kg (0.44 to 0.53 lbs) per day (Robbins and Moen 1975; Verme and Ullrey 1984). Thus, we assumed the fawn weighed approximately

3.5 kg (7.7 lbs) at birth and gained approximately 15.2 kg (33.5 lbs) between its birth and death. Using body measurements and estimated weight gains, we back-dated from the date of collection, suggesting the fawn was 63-76 days old and was born between 26 December 2006 and 8 January 2007. Assuming a gestation period of between 196 and 213 days (Haugen and Davenport 1950; Verme 1965, 1969), conception likely occurred between 14 and 27 June 2006. Also, physical examination indicated the fawn was in good physical condition with obvious white spotting on a relatively coarse hair coat. Admittedly, we used typical daily weight gains previously reported for fawns born during late spring or early summer (i.e., when nutritious forage is abundant) to estimate age and breeding and conception dates. Given the estimated birth date, it is possible that energy acquisition was limited and impeded growth in this individual due to reduced availability of nutritious food resources and limited milk production by the lactating mother during winter months. Consequently, breeding activity and the subsequent birth date may have occurred earlier than our estimates.

Reasons for late conception may be associated with nutritional limitations or winter weather conditions (DePerno and Anderson 2000). Although unlikely in the farmland region of southern Wisconsin, local nutritional limitations may exist. Verme (1965) noted that adult female deer on low quality diets initiated breeding activities several weeks later than individuals on higher quality diets. Van Deelen et al. (2007) reported a female deer from southern Wisconsin carrying five fetuses and McCaffery et al. (1998) noted that fetal rates among yearling and adult female deer in southern Wisconsin varied from 1.7 to 2.0 fetuses per pregnancy, indicating that high quality food resources are available throughout the farmland region of southern Wisconsin.

Late conception may be associated with mild winter weather conditions and deer breeding age. Because age of the breeding female was unknown, we were unable to determine the influence of breeding age. However, Raedeke et al. (2002) noted lower reproductive success in older-aged (i.e., ≥ 7 years of age) Elk (*Cervus elaphus*) while Rosatte and Neuhold (2006) suggested that age of a cow Elk (i.e., 11 years) may have contributed to her inability to meet annual energy requirements for normal reproduction and subsequent late conception and parturition dates during their study. Alternatively, DePerno and Anderson (2000) suggested that mild winter conditions may have extended estrous in a female deer fawn in southern Minnesota, partly explaining their observation of a late-born fawn. Verme and Ullrey (1984) suggested that yearling female deer achieved estrous later than older aged adults while Cheatum and Morton (1946) and Clark (1981) noted that fawns were bred one month later than adults. Also, female deer evidently experience recurrent estrous cycles (Plotka et al. 1977). For example, Cheatum and Morton (1946) suggested that females were capable of cycling into January, while Knox et al. (1988) reported two to seven estrous cycles in adult female deer and a potential breeding season of 172 days. It is possible that an older-aged female deer may have been unable to meet annual energy requirements for normal reproduction, which contributed to late conception and parturition observed in the present study. However, Woodford and McCaffery (2006) concluded that mild winter conditions during 2005 did not contribute to excessive mortality or depressed spring fawn production, and that deep snow conditions were limited throughout northern Wisconsin and absent by April when deer were most vulnerable to winter effects. To this end, it is also possible that a young White-tailed Deer reached sexual maturity during December 2005 and experienced multiple (6-8) estrous cycles before successfully breeding in mid to late June 2006 and consequently giving birth in late December 2006 or early January 2007.

Despite this uncertainty, we suggest that favorable winter conditions and distribution of farmlands throughout southern Wisconsin likely enable deer to maximize growth and reproductive effort at younger age classes, thus contributing to atypical breeding and parturition activities. Moreover, Rosatte and Neuhold (2006) suggested supplemental feeding may have enhanced survival of a late-born Elk calf by providing sufficient energy for the lactating cow to continue milk production during winter months. We further suggest that abundant food resources throughout the southern farmlands minimized potential growth impediments of this fawn by providing sufficient energy for the lactating mother to continue milk production during the winter season, thereby minimizing potential biases in our estimates of age, birth date, and conception dates.

Nonetheless, the sporadic observation of late-born fawns throughout the farmland regions of Wisconsin highlights the need for a greater understanding of the underlying factors that potentially contribute to late breeding activities by White-tailed Deer throughout the Midwest and Great Lakes states. It may be that by monitoring occurrence of late breeding activities that wildlife biologists may be able to identify additional factors affecting deer population dynamics.

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Book Reviews

Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, U.S. dollars are USD, Euros are EUR, China Yuan Remimbi are CNY, Australian dollars a AUD and so on. You will find these are the codes now used by financial institutions and internet currency converters. I will include an updated note for the next few issues as a reminder.

ZOOLOGY

Evolution and Biogeography of Australasian Vertebrates

Edited by J. R. Merrick, M. Archer, G. M. Hickey, and M. S. Y. Lee. 2006. Australian Scientific Publishing Ltd., P. O. Box 68, Oatlands, NSW 2117, Australia. xxviii + 942 pages. 230.00 AUD Cloth, 170.00 AUD. Paper.

This massive tome, covering the current state of knowledge on how and why the Australasian vertebrate fauna came to be what and where it is today, is absolutely absorbing. There is a massive amount of content, supplemented by numerous illustrations of continental movements, possible movement corridors, fossil and extant organisms, phylogenetic trees, and reconstructions of extinct organisms and ecosystems. Furthermore, much of the writing, although detailed, is in an accessible and sometimes humorous form.

The book is subdivided into 38 chapters, each written by experts on their particular subject matter. These chapters are grouped into seven broad categories, five of them covering the major traditional vertebrate taxonomic subdivisions: fishes, amphibians, reptiles, birds, and mammals. The other two subdivisions provide introductory context (an introduction to systematics, the geological history of the Australasian region, historical and current climatic influences on evolution and dispersal, and the links between the biotas of New Guinea, Indonesia, New Zealand, and Australia) and a final section entitled "Accelerated Change – the Regional Future", dealing with modern techniques in molecular systematics, tracking of marine movements of Australasian pinnipeds, and the importance of conservation planning for the preservation of the unique biota of the region. The introductory set of chapters provides critically important background information for understanding the relationships of the various land masses that make up Australasia, how these land masses were arranged within the southern supercontinent Gondwana prior to its fragmentation in the Jurassic, the influence of rising and lowering sea levels during geological history, ancient climates and glaciation, and a plethora of other environmental attributes that have been instrumental drivers in the evolution and movements of vertebrates in this part of the world.

Because the focus of the book is on evolution and dispersal, there is heavy emphasis on the fossil record and on phylogenetic reconstruction. In virtually all chapters, there is a review of the fossil record, including early hypotheses of origins of the given taxonomic group, as well as the influence of recent discoveries of fossils, as well as of modern molecular and other systematic techniques, on revising those earlier hypotheses. Thus, these chapters provide not only a summary of what is now known or hypothesized, but also a historical perspective on how the concepts developed and changed. There is interesting information in these chapters for both the specialist and the generalist, and also for those interested in the history of science. I did find the introductory chapter on systematics to be somewhat dogmatic, downplaying older approaches and advocating phylogenetic taxonomy, when I believe that most systematists now realize that even the older approaches have something to offer and their results can be integrated into the more modern approaches. Nevertheless, on balance, all of the chapters dealing with the systematics and evolution of the various vertebrate taxa are enjoyable to read and packed with information.

The authors clearly had fun writing these chapters, with many of them having a very engaging style. To give you an idea of some of the interesting chapter titles and passages in the book, here is a small sample: "Eons of Fishy Fossils" [Chapter 7], "Furry Egg-layers: Monotreme Relationships and Radiations" [Chapter 26], "Humans among Primates" [Chapter 34], referring to *Deinosuchus*, the largest crocodilian ever to exist, at 15 m in length "This generalist crocodilian could have taken on its contemporary, *Tyrannosaurus rex*, and won" [Chapter 18], referring to a fossil lizard "*Huehuecuetzpalli* ... from the early Cretaceous of Mexico, surely one of the most frightening names in all of palaeontology ..." [Chapter 19], and regarding marsupial origins "A far more complete fossil record will be required before we can confidently finger any particular taxon as the "original" marsupial. Whether North America or Asia is ultimately honoured as the marsupial "homeland", a curious twist to the story is that Gondwana, specifically Australia, might be the point of origin of placen-

tals." Scattered throughout these chapters, there also are important messages regarding conservation approaches and philosophy. In Chapter 23, dealing with island biogeography and the patterns of distribution of birds in Australasia, the author makes the point that conservation-oriented management must be directed at the entire landscape, not just the reserves. In various chapters, there are interesting thoughts on the selection of conservation reserves through the use of genetic characteristics of target populations, and the value of corridors to the movement of organisms across the landscape.

There is so much of interest and value in this book that it is difficult to summarize all of it. Suffice to say that this book contains a great deal of detail, presented in an interesting way, and that anyone interested in the evolution and biogeography of vertebrates in Australasia, or in evolution generally, will find something of value to them in this book. I recommend it highly.

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A Wildlife Guide to Chile

By S. Chester. 2008. Princeton University Press 41 William Street, Princeton, New Jersey, 08540-5237 USA. 392 pages, 19.95 USD Paper.

This is a compact guide with a wide coverage. Not only does it cover birds and mammals, but includes reptiles, amphibians, butterflies, moths, marine life and flora. In addition there are descriptions of the Chilean landscape and a where-to-watch section. While it does not cover all wildlife, it does portray those you are likely to see in a typical trip. You get all this for less than 20 USD - a real bargain.

I was puzzled by the illustrations until I read they were a composite of scanned photos using Adobe Photoshop and a Cintiq monitor. The result is a photograph-like illustration arranged in the same format as a painted version. This works very well as the depictions are clear without the spurious shadows and odd shading that often plague pure photographs. This manipulation has allowed the author to show creatures at different angles, highlighting special field marks.

The sections covering birds, mammals, reptiles and amphibians follow the usual field guide format. The names are given in English, Spanish and Latin, with a listing of other names where appropriate. There follows a description of the key characteristics. This is essential as not all plumages are illustrated. So you have to read to know that a female Vermillion Flycatcher is radically different from the male. There are no range maps, but ranges are written and you need to refer to the country maps at the front of the book.

The plants are presented somewhat differently. The author has them organised into eight zones and she describes and illustrates a dozen or so key species in each zone. Some, like Opuntia, are presented at the genus level only. In total the book covers less than 100 species or about 2% of Chile's plants. For example, there are three orchids out of the fifty species listed for Chile.

Similarly, about one third of the frogs and only four snakes are illustrated. This is not as Spartan as it sounds. On a typical trip I usually see a few of the commonest species of frogs and I average seeing one snake for every 10 days in the field. Similar comments can be made about the butterflies and moths.

The author has added numerous sections on basic natural history [e.g. Life of a frog or butterfly] throughout the text. While these are informative and fun, I am not sure they should be in a guide. Typically you want to compromise between expanding coverage and reducing weight. Also they tend to be rather curt and overly definitive. For example, the short explanation on the characteristics of butterflies and moths says moths fly by night. Most, but not all do.

The regional coverage includes mainland Chile and Easter Island, Desventurades Islands, Juan Fernandez Archipelago and the Chilean Antarctic Territory. The text includes location, a little history, a physical description and coverage of the key species [especially endemics]. In particular there is a short, but interesting, coverage of Antarctica.

I believe this would be very useful as a guide in the field. The coverage is good for mammals and birds and is adequate for plants and the other animals. The illustrations show the key characteristics as well as any other method. Take, for example, the three stocky skuas, Chilean, Brown and South Polar; the text and plates do as good a job as can be expected on these difficult species. While it does not contain as many juvenile, female and flight illustrations for the small birds as Jaramillo's book [*Birds of Chile*. By A. Jamarillo. 2003. Princeton University Press, New Jersey], for the other sections it is really good. The large birds, such as albatrosses, hawks, and shorebirds are typically shown in flight. I would prefer to have depictions of, say, female siskins so I would take this and Jamarillo's book on any trip to Chile. For the Chilean Territories, however, this guide is a must.

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Ecology & Evolution in the Tropics: A Herpetological Perspective

Edited by Maureen A. Donnelly, Brian I. Crother, Craig Guyer, Marvalee H. Wake, and Mary E. White. 2005. University of Chicago Press, Chicago, Illinois. x + 675 pages. 45 USD.

This volume contains most of the papers presented in a symposium held as part of the 2000 joint meeting in La Paz, Baja California, Mexico, of the three major herpetological professional groups in North America: The American Society of Ichthyologists and Herpetologists, the Society for the Study of Amphibians and Reptiles, and the Herpetologist's League. The symposium was organized as a tribute to the submission of the manuscript *The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, between Two Seas* (ultimately published in 2002, University of Chicago Press) by Jay Mathers Savage, and the latter's lifetime accomplishments in promoting long-term study of tropical diversity.

The contents are divided somewhat awkwardly but equally (9 chapters each) between (I) Evolution and Biogeography and (II) Ecology, Biogeography and Faunal Studies. The content is heavily weighted (13 of the 18 contributions) on tropical American species, not surprising, perhaps, considering Central and South America's richness in species and diversity. These American studies range from molecular phylogeny of caecilians, diversity of Costa Rican salamanders, an endemic Honduran frog, chromosomal variation in a group of southern Central American frogs, secondary sexual characters in tropical frogs, selection and male reproductive success in a neotropical frog, co-occurrence of hylid frogs in a temporary wetland, frog-eating anurans in the Paraguayan Chaco, biogeography of the anole genus *Norops* and of bothropoid pitvipers, and herpetofaunal analyses of the Rincon Area in Costa Rica, a Guyanan rainforest, and the Guayana highlands. The one Old World contribution is a long-term frog monitoring in Papua New Guinea, The four primarily overview contributions on a wider geographic scale are on phylogenetic taxonomy as a replacement for the Linnean system, on snake phylogeny based on Ribosomal DNA and morphology, elapid relationships, and theories of snake mimicry.

There are 27 contributors, many well known in the herpetological literature, others less so (in order of appearance): Arnold G. Kluge, Marvelee H. Wake, Gabriela Para-Olea, Judy P. Y. Sheen, David B. Wake, W. Ronald Heyer, Rafael O. de Sa, Sarah Muller, Shyh-Hwang Chen, Sharon B. Emerson, Mary E. White, Maria Kelly-Smith, Brian I. Crother, Joseph B. Slowinski, Robin Lawson, Harry W. Green, Roy W. McDiarmid, Karen R. Lips, Craig Guyer, Maureen A. Donnelly, Norman J. Scott Jr., A. Luz Acquino, David P. Bickford, Kirsten E. Nicholson, Steven D. Werman, Roy W. McDiarmid (again), Jay M. Savage, Maureen A. Donnelly (again), Magan H. Chen, Graham G. Watkins, Roy W. McDiarmid (again) and Maureen A. Donnelly (again).

This is not a comprehensive anthology of tropical diversity of amphibians and reptiles but rather selective glimpses from a random assortment of studies. Even as such it samples effectively the range of research into these in the southern climes and their importance in perspective of the variation of these groups in the world. The baseline studies presented are of particular importance in this era of unprecedented habitat destruction and climatic change after a period of relative stability against the background of well publicised observations of amphibian declines and the more poorly studied condition in reptiles.

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Fossil Ecosystems of North America: A Guide to the Sites and Their Extraordinary Biotas

By John R. Nudds and Paul A. Selden. 2008. The University of Chicago Press, Chicago. 288 pages, 39 USD Paper.

Fossil Ecosystems of North America is a science book, travel guide, mystery story, and historical saga in one package — a must-read for any naturalist with an interest in fossils, evolution, and geological time. Written by paleontologists John R. Nudds, University of Manchester, and Paul A. Selden, University of Kansas, it is a North American sequel to the 2004 *Evolution of Fossil Ecosystems*, in which the authors focused on 14 renowned fossil sites around the world.

Their new book features just as many sites, all located in North America, including three Canadian locations, one site which spans the Canada-United States border, and another in the Dominican Republic. Each site is covered by one chapter, with sub-sections devoted to its evolutionary context, its discovery and subsequent research, its stratigraphic setting, biota, and paleoecolgy, and comparisons with other similar sites. An appendix, written in true travel guide fashion, provides details on exploring the fossil locations and visiting related museums.

The Canadian sites, interestingly, contain evidence of the oldest biota. They include northern Ontario's Gunflint Chert, Newfoundland's Mistaken Point, and, probably Canada's best known fossil site, the Burgess Shale in British Columbia, also a UNESCO World Heritage Site.

The Gunflint Chert in northern Ontario, discovered in 1953 by geologist Stanley Tyler, has recently been dated at a staggering 1878 million years, which places it in the Paleoproterozoic era. It helps tell the story of

life without oxygen on the planet, of a time when only bacteria lived here, in rich and unusual diversity.

The evidence of early microbial ecosystems found at the Gunflint Chert includes filamentous, spherical, and star-shaped bacteria, as well as the curious and graceful umbrella-shaped *Kakabekia* bacteria, with its spheroidal bulb, slender stipe, and umbrella-like crown. All the fossils in the book are depicted in a combination of photographs and drawings.

The fossils at Mistaken Point on Newfoundland's Avalon Peninsula were discovered in 1967 by Shiva Balak Misra, an Indian graduate student studying at Memorial University. They help fill a critical gap in the history of life on Earth: the span between the microbial ecosystems of the Precambrian era, and the animal ecosystems of the Phanerozoic.

Mistaken Point biota range from disc-like *Aspidella*, to frond-shaped *Charnia* and bush-shaped *Bradgatia*. One of the most unusual shapes is *Triforillonia*, with its three-lobed body and rounded lobes radiating from a central rosette, possibly a holdfast or polyp-like organism. The particularly rich array of fossils preserved at Mistaken Point — a census population of thousands of individuals — offers valuable snapshots of living communities at the moment they were smothered by volcanic ash.

Fossil Ecosystems of North America is a fascinating book, easy-to-read, with highly comprehensible scientific explanations, extensive details, and helpful maps, photographs and drawings. It is, essentially, a riveting mystery story about life on this planet, filled with cataclysmic events, extinctions, takeovers, and human quests for clues and explanations, often involving conflict and heated debate. At another level, *Fossil Ecosystems of North America* is a science book for students and an interested lay readership. At yet another level, it is an unusual and informative "time travel" guide. Three books in one — a valuable addition to the bookshelves of any naturalist curious about deep time.

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Headless Males Make Great Lovers and Other Unusual Natural Histories

By Marty Crump. 2005. University of Chicago Press, Chicago, Illinois, USA. 199 pages. 25.00 USD Cloth, 14.00 USD Paper.

Marty [Martha] Crump, herpetologist, author of *In Search of the Golden Frog* (University of Chicago Press) and *Amphibians, Reptiles, and Their Conservation*, has compiled a remarkable collection of capsule glimpses of diverse natural history behaviour. Five section headings set the text style: Ain't Love Grand, The Mamas and the Papas, Eat to Live and Live to Eat, Don't Tread on Me, Ya Don't Say, but the serious reader should not be put off by this flippant approach — its aim is merely to grab the attention of readers who would not normally pick up a natural history book. The science is authoritative and reliable.

The detailed documentation of the scientific literature, on which the text is based, is contained in a 10-page concluding section arranged by topic with similarly innovative headings: Rampant Machismo, Come Up and See My Etchings, Sneakers and Deceivers, Survival of the Pampered, Nests Aren't Just for the Birds, Babies on Board, A Pouch Full of Miracles, Stomping for Worms, A Team Effort: How (Some) Ants Get Food, Chameleons of the Sea, Tears of Blood, Casting the Insides Outside, Spit 'n' Spray, Living Flashlights, Rapturous and Rapacious Reptiles, Smelling is Understanding, Love Potion Number Nine, It Pays to be Neighborly. This is followed by a seven-page index of organisms in the text.

This is a book ideally suited for idle moments or bedtime reading, the entries are as short and punchy as the section headings. The multitude of observations are gleaned and summarized from an amazingly vast diversity of research by ethologists and naturalists around the world. The title comes from the generally well-known mating of certain spiders where the female decapitates the male while he is still in the process of copulation. But the text covers a vast array of other behaviours, such as the stomping of Wood Turtles to bring the earthworms cherished as food to the surface. It is a remarkable testament to the seemingly endless variety of life styles and unique behavioural innovations present in the animal world, and is highly recommended to all naturalists for both education and amusement. The text is enlivened by sketches by Alan Crump.

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State of North America's Birds of Prey

By Keith L. Bildstein, Jeff P. Smith, Ernesto Ruelas Inzunza, and Richard R. Veit. Nuttall Ornithological Club and The American Ornithologists' Union, Series in Ornithology (3) 2008. Softcover. 466 pages, 98 figures, 42 tables, 6-page glossary.

This is the third volume in a promising and commendable new series of ornithological publications, each appreciably larger than the AOU Monographs of long standing.

The book begins with a succinct history of raptor conservation by senior author Keith Bildstein. He tells the history of bounties as a method of raptor control. Between 1917 and 1952, Alaska paid bounties ranging from 50 cents to two dollars on over 128 000 Bald

Eagles, in spite of the bird being the American national emblem. Bounties were an expensive method of controlling predators; for example, farmers in Pennsylvania may have saved only one dollar's worth of chickens for each $1205 in bounties paid by the state.

Most members of the public viewed hawks and owls as enemies to be shot on sight. "The only good hawk is a dead hawk," people would rationalize. In Pennsylvania, so-called sportsmen thronged to specific sites along the margin of Hawk Mountain to engage in wholesale killing of most species of raptor that flew by.

Those who believe that a single person can do little to change conservation practices will be impressed by the story of Rosalie Edge, who purchased a portion of Hawk Mountain that included the shooting sites. She then hired a warden to police the land. Against intense local opposition, the land was posted and hunters were deprived of the best place in all Pennsylvania to shoot the state-bountied Northern Goshawk. Because of Rosalie's vision and determination, Hawk Mountain has become a major educational and conservation center, increasing in importance each year.

This book lists each of the growing number of raptor monitoring sites, more than one hundred, where keen volunteers flock to help. The greatest effort is given to the fall migration. The "Veracruz River of Raptors" has posted numbers as high as 5.26 million in a single fall migration. There, the top four species are the Turkey Vulture, just shy of 2 million, Broad-winged Hawk at 1.92 million, Swainson's Hawks up to 915 000 and Mississippi Kites an impressive 155 000. A million Turkey Vultures have also been counted at Kekoldi in Costa Rica.

This book is replete with maps, graphs and tables. Seven excellent maps, for example, together demonstrate the impressive band recoveries for Sharp-shinned Hawks. Movements of many other raptors, however, are less well known and knowledge of their population levels is limited.

Raptor monitoring in Canada receives appropriate attention. Since hawks only come together in increasing numbers as they move south, they do not coalesce into large flocks in some parts of Canada. An exception are the 107 000 Broad-winged Hawks counted during the 1996 fall migration at Holiday Beach near Windsor, Ontario. There are three sites in Quebec where over 1 000 of one raptor species may be counted in a single day. Ontario has ten sites, including Hawk Cliff, and there are two each in Manitoba and British Columbia. In Alberta, at Windy Point, manned since 1967, over one thousand each of Sharp-shinned Hawks and Golden Eagles may be counted passing by. At nearby Mount Lorette, the Golden Eagle count can reach the neighbourhood of 4700. Canadian contributors to the book include David Hussell, a pioneer in developing the Raptor Population Index, a new counting method that aims for more consistency in raptor counting. Erica Dunn is the lead author for the Watchsite Methods chapter.

While insect-eating and ground-nesting birds continue to decline across North America, there is more good news than bad from the raptor front. While Northern Harrier and American Kestrel are diminishing at many sites, Swainson's Hawks, Bald Eagles, Peregrine Falcons and Turkey Vultures are generally increasing. The ground-nesting harrier is at risk from many predators, but it makes less sense that the kestrel, with relatively safer nest sites in boxes and cavities, should also be in decline. The impact of habitat changes, weather and food availability is being studied for many species.

There are minor defects in this compendium. There is a misleading absence of "Diurnal" before "Birds of Prey" in the title. Owls are not included, although the four-year cyclical irruptions of the Great Gray Owl and Northern Hawk-Owl can be dramatic. We are told in one sentence that irruptive migrations of the Northern Goshawk "occur periodically in years of low prey availability" but we are not told that this is part of a general 10-year cycle involving hare, lynx and Great Horned Owls. In the section on types of migration, "irruptive migration" should have been added to "loop," "altitudinal" and "leap-frog" migrations. The book lacks a detailed index.

Despite these minor flaws, this book belongs in the library of every raptor enthusiast and in every university and college library. Some chapters warrant reading in their entirety and others are excellent reference material. Anyone with the slightest interest in the rapidly growing field of hawk monitoring should read the salient chapters, and become aware of the contents of the others.

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Owls of the United States and Canada: A Complete Guide to Their Biology and Behavior

By Wayne Lynch. 2008. University of British Columbia Press, 6344 Memorial Road, Vancouver, British Columbia V6T 1Z2. 242 pages 39.95 CAD Cloth.

Wayne Lynch is an accomplished photographer and writer, I had no expectations that his newest book would represent anything less than the standard for which he is known.

The list of "things I would do differently" is quite small, but worth mentioning. The title, *A complete guide...* strikes me as being somewhat pompous... we know so much about owls that offering up a single tome as being somehow *complete* is a bit much. Then there's the tank of information yet to be discovered! Secondly, I'd be willing to bet that the vast

majority of research that was done by the original biologists was reported in metric. However, all of that was converted to imperial, rounded off and reported as such; parenthetically, the imperial values were reconverted and oft-reported as inappropriately-accurate metric values again, which muddles the original values and makes the reading stumbly. Both the birding and ornithological literature have long used a convention of capitalizing bird names; this avoids some potential confusion when, for instance, referring to "the Northern Hawk Owl" (the species) versus "the northern hawk owl" (the hawk owl found more northerly than others). I find newspapers reticent to adopt this standard, but there's no reason for this book to have done so. Those well-read in bird literature will do mental hiccups frequently while reading this book.

Chapters often start with a journal entry or description of an individual encounter with owls that beautifully sets up the chapter's theme. By doing this, Lynch maintains a personal connection with readers, which then encourages them to continue reading the more-matter-of-fact, but still very well-written material later.

There is a nice 10-page identification guide to the owls, with range maps and a synopsis of information such as habitat preferences, life span, diet and status. Although the text is good, the maps are deceptive. Unlike most field guides, the maps here use only one colour to report the species' ranges. And if you didn't know any better, you'd think the Snowy Owl bred everywhere in Canada, and into the northern tier of the United States (which it doesn't). Johnsgard's book on North American Owls does more justice to the ranges.

The rest of the book is written topic-by-topic, much like Duncan's *Owls of the World*. Other owl books, like Mikkola's *Owls of Europe*, take a more species-by-species account, with a few introductory chapters on topics like food, anatomy, movements, etc. I don't think one format can be said to be better than the other in general, each excels for different reasons. The approach adopted by Lynch makes for a more coffee-table friendly book; different species can be depicted in any one chapter, making comparisons among, for instance, insectivores to carnivores, readily apparent.

Throughout the book are sidebars containing synopses of topics related to the chapters' contents. I've always liked this approach as it allows for information that is otherwise not readily incorporable to be presented. In this book, the topics range from the pH scale (used to discuss digestion) to brooding behaviour.

Finally...the photographs. Dr. Lynch is perhaps best-known for his stunning photography. There are some awe-inspiring habitat shots, and double-page spreads that leave the reader with a sense that "I must visit that place." The shots of the owls themselves rate with the best I've ever seen and include depictions of some behaviours that are not frequently seen. Not to diminish the writing at all, but the photographs really make this book what it is.

Literature Cited

Duncan, J. Owls of the World: Their Lives, Behavior, and Survival 2003. Firefly Books, 66 Leek Crescent, Richmond Hill Ontario L4B 1H1 319 pages

Johnsgard, P. 1988. North American Owls: Biology and Natural History. Smithsonian Institution Press, Washington. 298 pages

Mikkola, H. 1983. Owls of Europe. Buteo Books, Vermillion. 397 pages

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Owls of North America

By Frances Backhouse. 2008. Firefly Books Ltd, 66 Leek Crescent, Richmond Hill Ontario L4B 1H1. 215 pages, 34.95 CAD Cloth.

Owls of North America, by Canadian writer Frances Backhouse, is a beautiful book — literally. The first thing I did when it came into my possession was to look at the photographs. A Great Horned Owl silhouetted against a sunset. A close-up of the same species' primary flight feathers. An Elf Owl delivering a cricket to its cactus nest. The large eyespots on the back of a Northern Pygmy-Owl's head. Great Gray Owls engaging in mutual preening. A young Long-eared Owl hanging upside down from a twig. A Short-Eared Owl stretching its leg as a warm-up to hunting.

I would have been thrilled with the book for the photographs alone. When I started reading, it got even better. Eight chapters discuss topics covering a wide range: owl and human relations, owl family groupings, life trajectories, feeding habits, communication, adaptations for nocturnal life, and more. Almost 80 pages are devoted to relatively comprehensive species profiles that provide photographs, maps, and details on appearance, voice, activity, roosting, distribution, habitat, feeding, breeding, migration, and conservation. A glossary and bibliography complete the information offerings.

The book brought alive owl species I was only vaguely aware of. The Elf Owl of the southwest, the world's smallest owl, which feeds mainly on insects. The Flammulated Owl of the west, also an insect-eater, with ventriloqual abilities that make singers difficult to locate. The Vermiculated Screech-Owl of Mexico, Central and South America, which sings like a toad.

The book also deepened my understanding of owls which are more familiar to me. The Great Horned Owl, that consumes a greater diversity of prey — from grasshoppers to great blue herons — than any other North American owl. The Great Gray Owl, which is benefiting from nesting platforms; one study revealed that nesting success was higher on platforms than natural nest sites.

The Eastern Screech Owl which, in Texas, brings live Texas blind snakes to its nest to eat the soft-bodied larvae of insects attracted to pellets, fecal matter, uneaten food, and occasional dead nestling accumulated in the cavity. The Burrowing Owl, which produces a sound remarkably like a rattlesnake's rattling buzz — a sound that may have evolved to deter predators such as badgers and weasels from entering nest holes. It has also, the author writes with a twist of humour, "definitely proven effective on occasion in discouraging ornithologists from reaching blindly into burrows."

Owls, the book clearly communicates, are fascinating earth residents with unique skills and adaptations that equip them for important ecological roles. As such, they deserve admiration, respect, and help in reversing the habitat loss from which virtually all owl species suffer.

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The Tree of Life: A Phylogenetic Classification

By Guillaume Lecointre and Herve Le Guyader. 2006. The Belknap Press of Harvard University Press, Cambridge, Massachusetts. 560 pages. 39.95.USD.

Here is a textbook to usher in the 21st Century based on the use of cladistics and the steadily increasing data from molecular biology. These have been gradually changing systematic biology over the past 30 years. It may not be the last word in this dynamic field but it certainly is in the current mainstream. It presents a genealogical approach to classification of the diversity of all life on earth through the phylogenetic analysis increasingly promoted by many researchers as the successor to the Linnean System. The latter was outlined for plants in 1735 and for all organisms in 1758 and thereafter long universally adopted and taught throughout the world. The Linnean system accepted the concepts of its time — divine creation and the Great Chain of Being, each individually created group of organisms, from single celled to human, conceived of as progressively "higher" with *Homo sapiens* as the culmination. After a hundred years, in 1858, Charles Darwin outlined descent with modification by natural selection which showed how evolution could occur. Shortly after, in 1866, Ernst Haeckel coined the term phylogeny but it was nearly a hundred years later before Willi Hennig outlined the comprehensive application of an objective cladistics approach (phylogenetic systematics) published in German in 1950 and in English in 1966.

The Tree of Life outlines major groupings for the present estimated 1 749 577 described and currently recognized organisms. After a preface and introduction there are 15 chapters. The initial one on "Life" is followed by Eubacteria, Archaea, Eukaryotes, Chlorobionta, Embryophyta, Metazoa, Protostomia, Mollusca, Eurarthopoda, Deuterostomia, Sarcopterygii, Mammalia, Primates, Actinopterygii. Some group names are familiar from traditional classifications, some will be new and strange to most naturalists. Abolished are familiar classification categories (Kingdom, Class, Order, Family) to be replaced by diagrams (dendrograms) depicting relationships. Also vanished are what are now regarded as mixed groupings such as reptiles and fish.

Each chapter is subdivided and a chart presented of the relationships of the included forms discussed. Each grouping has line drawings of example organisms and features, a brief general description of included forms and sections on ecology, some unique derived features, and examples of included forms. A sidebar gives number of species, oldest known fossils, and current distribution.

The book concludes with 13 Appendices of "trees" showing the cladistic view of relatedness, and including "Where are they" giving the new positions of major traditional groups of both one-celled and multicelled life, Sequenced Genomes (listing organisms for which the genome is entirely sequenced or almost so as of January 2006), a one-page General Bibliography, a Glossary of 70 entries from Alignment to UPGMA (Unweighted Pair Group Method Using Arithmetic Average), Index of Common Names and Index of Latin Names.

The intent of the volume is to move this phylogenetic approach to classification out of its currently restricted academic position and bring it into the mainstream to replace the traditional teaching now rendered archaic, at least in the view of the presenters. The authors are well suited to the task, throughly immersed in the modern concepts and teaching. Lecointre is Professor and Research Scientist at the Museum National d'Histoire Naturelle and Le Guyader is Professor of Evolutionary Biology at the University of Pierre and Marie Curie, both in Paris, France. The book was originally published as *Classification phylogenetique du vivant* (third edition, Editions Belin, Paris, 2006) and translated by Karen McCoy. It is illustrated by Dominique Visset.

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Biology of the Snapping Turtle (*Chelydra serpentina*)

Edited by A. C. Steyermark, M. S. Finkler, and R. J. Brooks. 2008. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363. x + 225 pages 75 USD.

The *Biology of the Snapping Turtle* consists of 17 review papers on various aspects of the life history of one of the most recognizable turtles of North America. Part 1, Taxonomy and Systematics, consists of four chapters covering the systematics of the family Chelydridae, the fossil history of the family, the anatomy of the skull, and molecular insights into the systematics of the family. Part 2, Physiology, Energetics, and Growth, consists of seven chapters covering such disparate topics as respiration, reproductive physiology, thermal ecology, energetics, embryology, overwintering adaptations and growth patterns. The final section of the book, Life History and Ecology, consists of six chapters on nesting ecology, water relations of the eggs, sex determination, physiology of hatchlings, population biology and geographic variation in life history traits.

Although many of the chapters are strictly review papers, a number of the authors have included previously unpublished data from their own work or the work of others. For example, H. Bradley Shaffer and his co-authors include their analysis of the genetic variation across the currently recognized four subspecies of Snapping Turtle. Their results are consistent with earlier less extensive work: first of all, there is no molecular evidence to support the recognition of the Florida Snapping Turtle *C. s. osceola*) as a distinct taxa; second of all, the Central American Snapping Turtle *C. s. rossignonii*) and the South American Snapping Turtle *C. s. acutirostris*) both appear to be separate evolutionary lineages and should be viewed as separate species.

While many of the papers in this volume are tightly focussed on the Snapping Turtle, a number of the papers could just as easily have appeared in a volume on the biology of turtles in general. For example, Gordon Ultsch and Scott Reese's paper on overwintering is a thorough review of the literature on turtle physiology with regards to hibernation.

Overall, the quality of the papers is high. One of the highlights of the book is the chapter on nesting ecology written by researchers involved in three long-term studies of Snapping Turtles at Algonquin Park, Ontario; the Edwin S. George Reserve, Michigan; and the Savannah River Site, North Carolina. There are also a few careless mistakes in the book that more careful editing could have caught. The Wood Turtle (*Glyptemys insculpta*) and the Bog Turtle (*G. muhlenbergii*) are still placed in the genus *Clemmys* in the text and in the index. There is also more overlap in material than is required. Growth of the embryo is discussed in both the chapter on the embryo and the chapter on growth. The relationship between clutch size and body size is thoroughly charted in the chapter on nesting ecology, discussed in the chapter on population biology and re-visited in the chapter on geographic variation. The editors are also strangely silent. There is no introduction from them explaining the origin or rationale for the volume or any kind of concluding chapter synthesizing the themes of the volume. Nonetheless, anyone with a technical interest in the biology of turtles (not just Snapping Turtles) will find this an extremely valuable reference work.

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Wildlife of North America: A Naturalist's Lifelist

By Whit Bronaugh. 2006. University Press of Florida, Gainesville, Florida, USA. 565 pages. 29.95 USD.

This is a bold and daring compilation that few would have the courage to undertake and present. It is a contribution to the attempt to promote systematic record keeping by the vast number of casual or non-academic naturalists. The volume is essentially a checklist of all native and introduced mammals, birds, reptiles, amphibians, freshwater fishes, butterflies, dragonflies and damselflies recorded to date for North America. These groups include relatively large and often conspicuous animals for which a naturalist can identify a significant number of species on sight.

It is based on the latest (at the time of publication) authoritative listing for each group with the full realization that work is ongoing for all group names and species recognition is constantly changing with each new study that produces new knowledge that necessitates revisions. Despite this, probably enough stability has been reached in each included group that names used here will still be able to at least be equated with those that will be current in another decade or two hence.

The contents include a Preface (the author's purpose and how he came to compile the book and his acknowledgments), a Checklist of North American Orders and Families for the included groups, A List of Symbols (indicating species extinct and since when), an Introduction to the main text, How to Use this Book, Biodiversity and Zoogeography of North America (with maps of number of species in each province and state) and Extinct Species. The bulk of the book follows (pages 83 to 430) listing English and scientific name for each species by family and blank spaces for user remarks such as first observation date, place or other data considered relevant. The

are additional blank entry spaces at the end of each group section for addition of species defined after the publication of this book. The book concludes with an Appendix of recent taxonomic and nomenclatural changes which depart from standard field guides (pages 431-478), Works Cited (pages 469-478), Index to Scientific Names (479-528), and Index to Common Names (pages 529-565). The last two are particularly valuable for equating a name used in older field guides to the name recognized currently.

What this is not is a field book. It is far too large and bulky to be carried on outings. It is a book for post-expedition entries. It is devoid of keys or text on identifications, these are left to consultation of the many guides listed in the references. But even naturalists who may purchase the book with the best of, but later unrealised, intentions, will find it a valued quick reference for their library for its analysis of North America distribution patterns, comparative species totals, and post-Pleistocene zoogeography, among many other considerations, all carefully compiled from recent authoritative sources.

Whit Bronaugh now lives in Oregon and makes a living as a nature writer and photographer, but he grew up among the carefully manicured horse farms of central Kentucky and did not really discover nature until a university field course in Africa. He has remained in awe of the diversity of animal life ever since and, as an initial lifelist of birds expanded to include other groups, the concept to this book was generated initially to fill his own needs. His other work has appeared in popular periodicals such as *Wildlife Conservation*, *National Geographic*, *Natural History*, and *Smithsonian*. His photography presented here is restricted to a few small black-and-white reproductions in the book itself and colour ones on the attractive dust jacket.

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BOTANY

Grasses of Colorado

By Robert B. Shaw. 2008. University Press of Colorado, 5589 Arapahoe Avenue, Suite 206C, Boulder, Colorado 80303 USA. *xi* + 647 pages. 75 USD Cloth.

The grasses constitute one of the most important families of flowering plants in the world, both economically and ecologically. They are extremely diverse and generally comprise about one-tenth of the vascular flora in many parts of North America. They are dominant in many ecosystems, including several of the most extensive ecosystems in Colorado. *Grasses of Colorado* provides a thorough, up-to-date treatment of the 335 species of grasses known to occur outside of cultivation in the state. The book is arranged in several sections. The introductory section deals mostly with utilitarian aspects of grasses, including food and forage, soil conservation, turf and ornamental uses, and harmful grasses. The ecological significance of grasses receives rather limited discussion, despite the prominent role of the family in the state's major ecosystems. Following the introduction is a section on the physiography and ecoregions of Colorado which is informative and useful in understanding the distribution patterns of the grasses in the state. Maps outlining the major landforms, river systems, mountain ranges, and ecological subdivisions assist considerably in understanding these patterns. This section is followed by a chapter on grass morphology which contains good illustrations that cover most of the important features that are used in grass identification. These illustrations are particularly helpful when coupled with the illustrations of each species that are interspersed in the main taxonomic, descriptive part of the book.

The bulk of the book is comprised of the taxonomic treatments, including keys, descriptions of subfamilies, tribes, genera, and species, illustrations, and range maps depicting counties of occurrence. The species descriptions are quite detailed, including the important floral and vegetative characteristics. A concerted effort has been made to ensure that all descriptions are parallel, not just between species within a genus, but across all genera. Each species treatment also contains information on major synonyms, common names, origin (native vs. alien), a general habitat description, and a section for comments on status in the state, taxonomic issues, and similar species. The accompanying illustrations are reproduced with permission from the two grass volumes of the *Flora of North America* (Barkworth et al. 2003, 2007). These generally are excellent and, when used in conjunction with the keys and descriptions, should enable successful identification. On occasion, I found the comment subsection in the species treatments to be redundant (same information repeated for several species within a genus), but more often than not, there was useful supplementary information there.

In general, Shaw follows the taxonomic concepts espoused by other grass experts, as reflected in the *Flora of North America*. However, there are a few departures, such as the segregation of *Melica* into two genera, *Melica* and *Bromelica*, the segregation of *Bromus* into four genera, *Anisantha*, *Bromopsis*, *Bromus*, and *Ceratochloa*, corresponding to the sections of *Bromus* in most other North American treatments, and the separation of *Critesion* from *Hordeum*. Most of the rest of the taxonomic treatment will be familiar

to those who follow grass taxonomy, including the segregations and realignments of species within genera in the tribe Stipeae.

The content of the book generally is of high quality, and, as much as is possible with a group of plants that has its own set of descriptive terminology, the text and keys are readable with jargon minimized. There are occasional inconsistencies in the text; for example, in the treatment of *Digitaria sanguinalis*, under Origin, the species is said to be native, but in the Comments section, it is stated to be "a European species now established as a global weed." I detected relatively few proof-reading errors (e.g., synonym not italicized, punctuation misplaced, rare spelling errors), and these do not detract substantively from the book.

This book provides a welcome updated treatment of the grasses of Colorado. In spite of the fact that there is a recent North American taxonomic treatment of the family, there will always be a need for regional and local treatments, especially for large and diverse families such as this. The book should prove to be useful for the identification of grasses in several adjacent states, including much of the upper Midwest, from Montana to North Dakota and south to Kansas. It should also be useful in the southern portions of the Prairie Provinces.

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WILLIAM J. CRINS

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The Macrolichens of New England

By James W. Hinds and Patricia L. Hinds. 2007. Memoirs of the New York Botanical Garden Volume 96. New York Botanical Garden Press, Bronx, New York. 608 pages, 65.00 USD Cloth.

The most recent publication on lichens from the New York Botanical Garden is the first detailed treatment of New England macrolichens. Before the reader even opens *The Macrolichens of New England* the 14 beautiful photos on the front and back covers give the sense that it is something special. This much-awaited guide, drawing on 35 years of collected photos and knowledge of the lichenologist team of James and Patricia Hinds, describes and illustrates the lichen flora from a very unique region rich in lichen flora. The Hinds share with the reader a plethora of information ranging from specific species treatments to general lichen biology so it appeals to the serious professional and novice alike.

A quick key index inside the front cover provides the reader with direct access to a group or classification of their choice; a useful tool allowing this book to be used strictly as a field guide. The front sections should not to be overlooked as they provide, in much the same way as I. M. Brodo, S. D. Sharnoff, and S. Sharnoff (2001) *Lichens of North America*, 70 pages of useful information that will inform and help the reader to explore the world of lichenology. These early chapters provide essays on anatomy, ecology, lichen conservation and population trends, and identification. The general key section follows the background (approximately 30 pages) which will direct you into the genus descriptions (some 400 pages). The extensive references cited, glossary, two appendixes, and index, organized by Latin name, round out the book.

A total of 502 species is covered, including 308 with colour photos. Some of these species are extremely rare, not typically described in literature of this type. Included are species found in adjacent localities, which could occur in the region of study. Microlichens are briefly discussed in the introductory chapters but are not treated with the same detail as the macrolichens. Many of the species discussed have coastal affinities, with many others found inland, making this book a great resource for readers interested in species across the entire continent.

For the most part the photos are stunning, and beautiful, capturing key identification features needed for the reader to compare species observed or collected with the photos in the book and make accurate and correct identifications. Capturing the entire depth of field in macro photography is a common problem and generally the authors do a great job. Some of the images, however, suffer from poor depth of field sharpness and have blurred or fuzzy portions. (i.e., figures 111, 165, 272). There are many more stunning and beautiful images with great depth of field than with out. Species described without an image include a reference, when available, to another source where a photo was provided.

Two omissions of occurrence records should be noted. One was on page 51. When describing the rarity of *Leptogium rivulare* the authors suggest that the most recently known collections occurred in the early 1970s (Southern Ontario); however, collections of this species occurred in the early 2000s (Southern Ontario 2002 and Manitoba in 2003) and more recently in Southern Ontario in 2007 (not published). The second was a reference to the distribution of *Xanthoria parietina*, page 525, which is described as restricted to oceanic coastal areas. In general this is true but recent inland discoveries, including records in Southern Ontario (2002 and 2006); have been documented.

Using photographs only for identification can result in a misidentified specimen. In *The Macrolichens of New England* the blend of text and images will enable the user to avoid this error. There are incredible photos of very rare lichens not typically seen by the average lichenologist. The paired photo examples of various species showing the upper and lower surface (*Peltigera* sp.), wet thallus versus dry thallus (i.e., *Placidium arboretum*, *Physconia detersa*, and *Pyxine sorediata*), and macro versus micro features (i.e., *Leptogium*, *Sterocaulon, Usnea*) make this book incredibly valuable because some of these species can only be separated by comparing these features.

The book is 7 ½ inches wide 10 ¼ inches long and 1 ⅛ inches deep. It weighs approximately 2.0 kg. Although the book is by no means light, it is a more manageable field guide than Brodo et al, which is roughly twice the size and weight, making this book a more welcome field companion. I have toted both into backwoods locations and appreciated the size and weight difference. It has a hard durable cover with a small ruler drawn on the last page that could be used for field measurements. If taken into the field, however, the glossy covers will inevitably get scratched as there is no slip cover to protect it.

The authors tout this book as the "the most comprehensive work of its kind" and they deliver. This book, like Brodo et al., will be an instant classic. Those who read this book will have no choice but to be drawn into the world of these fascinating organisms.

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Wild Plants of Eastern Canada

By Marilyn Walker. 2008. Nimbus Publishing Ltd., P.O. Box 9166, Halifax, Nova Scotia B3K 5M8. 202 pages, 24.95 CAD.

Wild Plants of Eastern Canada was not what I expected. I was looking forward to another wild plant field guide, a cross-referencing source, a book offering additional details and visuals to aid in identifying those hard-to-pin-down native asters and goldenrods. That's not what *Wild Plants of Eastern Canada* is about.

My first reaction to the book was, consequently, mild annoyance – which developed into growing curiosity, then pleasant surprise the further I read. *Wild Plants of Eastern Canada* turns out to be more than a wild plant identification guide. Divided into three parts – (1) "Plants and People of the Northeast", (2) "Field Guide", (3) "Recipes" – the book is a human and natural history, an identification tool (of sorts), and a recipe book.

Part 2, the "Field Guide", takes up the most pages. It contains extensive information on each plant profiled, including scientific and "other" names, general information about the plant family, habitat details, a physical description of the plant, and, depending on the species, sections on usable parts, common uses, medicinal properties, and garden-related particulars. The accompanying black-and-white photographs are helpful, while the leaf prints add a subtle artistic touch.

The recipes covering almost 40 pages in Part 3 of *Wild Plants of Eastern Canada* are intriguing. They range from "classics" such as teas and bannock, to preparations using petals, buds, roots, and berries. I have not yet had the opportunity to test any of them, but I am looking forward to trying out goldenrod crepes, dandelion leaf sandwiches, and clover butter.

Part 1 of the book I found the most interesting and most trying. It was there, not far into the section, that I discovered the book's most frustrating limitation: its geographical scope. I had assumed the "Eastern Canada" part of the book's title to refer to the usual territory stretching from the Atlantic Ocean to the western end of Ontario. Yet *Wild Plants of Eastern Canada* ends up covering the Maritime provinces only — not a bad thing if that is what the reader is expecting. But as a Quebec resident, I was hoping my region was included in the book.

The rest of the information in Part 1 comes as a pleasant surprise. Rich in historical and anthropological detail, it provides a succinct and comprehensive overview of Atlantic Canada's paleoenvironment, European settlement, and Aboriginal history and culture, including First Nations traditional plant knowledge.

I found the first sub-section, "Like Plants, Like People" the most intriguing. There, the author writes: "Like people, plants are great colonizers. They wander about, singly or in "herds", trying out new conditions until they find somewhere to settle in. If the environment is not suitable, they go elsewhere out of necessity, or perhaps out of the same sense of adventure that inspired human migration" — an intriguing, and for me appealing, perspective.

My main gripe with the book is its main title. *Wild Plants of Eastern Canada* is misleading, and the extra text on the front and back covers does not provide any clues regarding the geographical scope of the book. Yet for individuals able to get their hands on it, the smaller typeface on the front cover — "Identifying, Harvesting and Using", "Includes recipes & medicinal uses" — provides helpful hints regarding the book's content.

Wild Plants of Eastern Canada is a welcome addition to the wild plants section of my bookshelves, despite its limitations and frustrations.

RENATE SANDER-REGIER

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MISCELLANEOUS

Sods, Soil, and Spades: The Acadians at Grand Pre and their Dykeland Legacy

By J. Sherman Bleakney. 2005. McGill-Queens Press, Montreal, Quebec, and Kingston, Ontario. *xxxii* + 221 pages. 14.95 CAD.

Sherman Bleakney is widely known in Canada as a zoologist of remarkeably diverse interests and publications. As curator of amphibians, reptiles and fish at the National Museum of Canada from 1952 to 1958 his expeditions from the Maritimes to Alberta doubled the national herpetology collection to 14 000 specimens. He published a ground-breaking analysis of the distribution of amphibians and reptiles in Eastern Canada (Bleakney 1958) based on his 1956 Ph.D. thesis from McGill University supervised by legendary Max Dunbar, the first Ph.D. in herpetology at a Canadian university (Cook 2007). In 1958 he returned to Nova Scotia where he had been raised, and to Acadia University where he had obtained his B.S.c and M.Sc., to teach zoology and where he has remained until and past retirement. Although initially his herpetological contributions continued there, particularly on both freshwater and marine turtles, he became increasingly immersed in publishing on fishes and invertebrates of the marine ecosytem of the Minas Basin, culminating in a book on nudibranchs (Bleakney 1996).

Since 1994 he has further broadened his environmental perspective and turned his critical trained eye and literary skills and enthusium to the dykes originally built by the French settlers (Acadians) along the Minas Basin at the head of the Bay of Fundy in Nova Scotia. The result is a fascinatingly detailed and throughly documented history and construction analysis, with sections on the geology, post-glacial events, and fauna of an area which boasts the world's highest tides and the land reclaimed and protected from them. For this he has been able to draw on written and oral accounts and has paid particular tribute not only to the builders but also to those who left an accurate record of techniques of dyking brought from the low countries of Europe and adapted to the local conditions.

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NEW TITLES

Prepared by Roy John

† Available for review * Assigned
Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars.

ZOOLOGY

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***Central Park in the Dark.** By M. Winn. 2008. Farrar, Straus and Giroux [Douglas & McIntyre Publishing Group], Suite 201, 2323 Quebec Street, Vancouver, British Columbia V5T 4S7. 263 pages, 27.50 CAD Coth.

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BOTANY

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News and Comment

Marine Turtle Newsletter (117) July 2007

25 pages: ARTICLES: Marine turtles in Mozambique: Towards an effective conservation and management program (A. Costa, H. Motta, M. A. M. Pereira, E. J. S. Videira, C. M. M. Louro, and J. Joao) — Predation on the zoanthid *Palythoa caribaeorum* (Anthozoa, Cnidaria) by a Hawksbill Turtle (*Eretmochelys imbricata*) in southeastern Brazil (S. N. Stammpar, P. F. da Sola, and O. J. Luiz Jr.) — Rat eradication as part of a Hawksbill Turtle (*Eretmochelys imbricat*) conservation program in an urban area in Cebedelo, Paraibaaa State, Brazil (D. Zeppelini, R. Mascarenhas, and G. G. Meier) — Morphodynamics of an Olive Ridley nesting beach in the Baja Peninsula (V. M.Gomez-Munoz, and L. Godinez-Orta) — NOTES: First records of Olive Ridley Turtles (*Lepidochelys olivacea*) in Seychelles (S. Remie and J. A. Mortimer) — Sexual harassment by a male Green Turtle (*Chelonia mydas*) (B. W. Bowen) — Incidental capture of a Leatherback along the coas of Ceara, Brazil (E. H. S. M. Lima, M. T. D. Melo, and M. H. Godfrey BOOK REVIEW — IUCN-MTSG QUARTERLY REPORT ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

The Marine Turtle Newsletter is edited by Lisa M Campbell, Nicholas School of Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516 USA; and Matthew H. Godfrey, North Carolina Wildlife Resources Commission, 1507 Ann Street, Beaufort, North Carolina 28516 USA. Subscriptions and donations towards the production of the MTN can be made online at <http://www.seaturtle.org/mtn/> or postal mail to Michael Coyne (Managing Editor) Marine Turtle Newsletter, 1 Southampton Place, Durham, North Carolina 27705 USA; e-mail: mcoyne@seaturtle.org.

The Boreal Dip Net/L'epuosette boreal 11(2) Summer 2007

Newsletter of the Canadian Amphibian and Reptile Conservation Network/ Reseau Canadien de Conservation des Amphibians et Reptiles

Contents: Editor's Note (Sara Ashpole) — Summary of 2006 Annual Meeting 27 to 29 October, Victoria, British Columbia (Jean Wai Jung) — Prairie Rattlesnake movement patterns though the City of Lethbridge (Wonnita Andrus) — Hibernation sites of Western Toads in Alberta (Constance Browne) — Prairie Skinks in the Manitoba sandhills: Determining a habitat suitability model (Nichlas Cairns and Pamela I. Rutherford) — The effects of de-icing salt (NaCl) on amphibian community structure in Nova Scotia (Sara Collins and Ron Russell) — Arguments, counter arguments and geneal mystification over new scientific names for amphibians (David M. Green) — Reptiles at risk on the road again! (Jeff Hathaway) — Fertilizers and enrichment of nitrogen isotopic signature in larval Green Frogs (Dale Jefferson amd Ron Russell) — Amphibian tropic interactions (Dale Jefferson and Ron Russell) — Seabird Island Oregan Spotted Frog Project (Keena McNeil) — Are Bullfrogs being spread by vehicles (Elke Wind) — Annual General Meeting 2007 Queens University, Kingston, Ontario 21 to 24 September — Critical habitat workshop — Fieldtrip — Member publications.

Alliance of Natural History Museums of Canada Annual Meeting and Awards

On 24 and 25 September 2007 the Alliance of Natural History Museums held its annual meeting in Ottawa. The ANNHMC is a network of Natural History Museums created in 2003 to enhance collaborative work in the areas of research, collections development, and education about the natural environment. The 12 founding members (from west to east) are the Royal British Columbia Museum, Royal Alberta Museum, Royal Tyrell Museum of Palaeontology, Royal Saskatchewan Museum, Manitoba Museum, Canadian Museum of Nature, Montreal's Nature Museums (Biodome, Insectarium, Botanical Gardens and Planetarium), New Brunswick Museum, Nova Scotia Museum of Natural History, and the Rooms, Newfoundland and Labrador. The Royal Ontrario Museum joined in the summer of 2007.

"By sharing knowledge and resources among member museums, we can impove our efforts in opening up the world of Canada's rich natural history to Canadians and educating them about important environmental issues" explained Johanne Landry, President of the ANHMc and Director of the Insectarium (part of Montreal Nature Museums). We have a stragegic plan in place and have completed a survey of our combined collections. This meeting was an important opportunity for our representatives coast to coast to come together and identify our next steps." Together, the member museums safeguard more than 19 million catalogued specimens of plants, animals, minerals and fossils collected over 150 years that are the record of Canada's natural history through time.

At a reception 25 September on Parliament Hill in Ottawa the Alliance welcomed the Royal Ontario Musuem as a new member and presented a new award, the Gold Leaf Award for significant contribution to the study of natural history in Canada to Dr. Francis R. Cook, researcher emeritus at the Canadian Museum of Nature and editor of the Canadian Field-Naturalist, and posthuously to the late Dr. Bruce Naylor, former director of the Royal Tyrell Museum of Paleontology and founding ANHMC president. The award has been renamed for Dr. Naylor.

Minutes of the 128th Annual Business Meeting of The Ottawa Field-Naturalists' Club 9 January 2007

Place and time: Canadian Museum of Nature, Ottawa, Ontario, 7:30 pm
Chairperson: Mike Murphy, President
Attendance: Twenty-six persons attended the meeting.

Attendees spent the first half-hour reviewing the minutes of the previous meeting, the Treasurer's report and the Report of Council. The meeting was called to order at 7:35 pm with some opening remarks from the President.

1. Minutes of the Previous Meeting

1. Under Report of the Nominating Committee; D. Kitching should be listed under "Members at Large"
2. Under Presentation of Awards for the 2005 OFNC Photo Contest, "The Grand Prize winner received a digital camera and photo printer donated by Galaxy Camera"
3. Grand Prize winner: Dave Sangster

It was moved by Henry Steger and seconded by Ann MacKenzie that the minutes be accepted.

(Motion Carried)

2. Business Arising from the Minutes

There was no business arising from the Minutes.

3. Communications Relating to the Annual Business Meeting

There were no communications relating to the Annual Business Meeting.

4. Treasurer's Report Frank Pope

Frank Pope reviewed the financial report for the year ending 30 September 2006, noting that the Club's net assets have increased by approximately $2000. Listed under "Other revenue" was the balance of a bequest from the estate of Mildred Groh ($23 717).

Frank answered questions from the audience with regards to the increased publishing costs of the CFN. He explained that this was due to the publishing of 4 issues in 2006 versus the 2 issues published in 2005. Several audience members spoke about electronic publishing as being the way of the future for scientific journals, and one which the CFN should actively consider.

Moved by Frank Pope and seconded by Ken Allison that the Financial Report be accepted as amended.

(Motion Carried)

5. Committee Reports

Mike Murphy asked for questions and comments on the Committee reports which had been distributed to the attendees. He thanked the committee chairs and committee members for their work over the past year.

Moved by Gillian Marston and seconded by Diane Lepage, that the reports be accepted.

(Motion Carried)

6. Nomination of the Auditor

Moved by Frank Pope and seconded by Ann MacKenzie, that Janet Gehr continue as Auditor for another year.

(Motion Carried)

7. Report of the Nominating Committee Eleanor Zurbrigg for Fenja Brodo

President	Mike Murphy
Vice President	Ken Allison
Secretary	Susan Laurie-Bourque
Treasurer	Frank Pope
Past President	Gary McNulty
Business Manager	Bill Cody
Editor CFN	Francis Cook
Editor T&L	Karen McLachlan-Hamilton

Committee Chairs

Birds	Chris Traynor
Computers	Dan Millar
Conservation	Stan Rosenbaum
E&P	Gillian Marston
E&L	Fenja Brodo
Finance	Ann MacKenzie
FWG	David Hobden
Membership	Henry Steger
Publications	Ron Bedford
ON Rep	Eleanor Zurbrigg

Members at large

Julia Cipriani
Diane Kitching
Annie Belair
Diane Lepage

Chairs not on Council

Awards	Ernie Brodo
Macoun	Rob Lee
Nominations	Fenja Brodo

Retiring from the council: Susan Howell, Justin Peter

New on the council: Annie Belair

Moved by Eleanor Zurbrigg and seconded by Frank Pope, that the slate of nominations for the 2007 Council be accepted.

(Motion Carried)

8. New Business

There was no new business.

There was a comment from a Club member on the need to involve the younger generation of Club members in Club activities. Ways of bringing these members together at the monthly Club meetings such as the use of name tags and formal introductions were discussed.

9. The OFNC Website; a virtual tour by our Webmaster Sandra Garland

The OFNC has a wonderful, informative website maintained by Sandra Garland. Sandra gave us a tour of the Website with aid of a laptop and digital projector. She informed us that the website was started 10 years ago by the E&P committee. Since then the site has grown to become the information rich resource for Club members and the public at large that it is today. Web statistics reveal that the site is actively used and accessed regularly.

Mike Murphy thanked Sandra for her excellent work and for her entertaining and informative presentation.

10. Adjournment

Moved by David Hobden and seconded by Diane Lepage that the meeting be adjourned at 9:35 pm.

(Motion Carried)

SUSAN LAURIE-BOURQUE
Recording Secretary

The Ottawa Field-Naturalists' Club Committee Reports for 2006

Birds Committee

The Birds Committee, in conjunction with the Club des Ornithologues de l'Outaouais, compiled the 2005 Christmas Bird Count. The fall bird count was held in October 2006 and was a successful event. This year marked the 10th anniversary of the Peregrine Falcon Watch. Commemorative hats were produced to mark the occasion. One male was successfully fledged. The Bird Records Sub-committee continues to review records of rare birds and has made Rare Bird Report forms available on the Club's web site. This year's Seed-a-Thon was successful in raising over $600.00 for Club feeders. A new feeder was built for the OFNC by the National Capital Commission and was installed at the Mer Bleu. The Committee continues to operate the Ottawa Bird Status Line and the Rare Bird Alert.

CHRIS TRAYNOR
Chair, Birds Committee

OFNC Computer Management Committee

The Computer Management Committee did not meet during 2006.

MICHAEL MURPHY
OFNC President

Education and Publicity

Kiosks, Displays and Other Events

The committee created another set of display panels for the large display using the Watershed as the theme. Committee members participated with displays at the Ottawa-Carleton Elementary Teachers' Federation Publishers' Display, National Wildlife Week's Wildlife Festival, several Environment Week events (National Resources Canada, Agriculture and Agri-food Canada, Citizenship & Immigration and National Defense), the Sierra Club 'People & the Planet' conference, and the OFNC Soiree.

Once again the OFNC participated in the Ottawa Science Fair sponsoring 3 prizes for projects co-judged by Jeff Sleevington and Ed & Pub committee member Kathy Conlan.

The committee also arranged speakers for outside groups. Several digital photo presentations were also made by committee members.

OFNC Membership Drive

The portable kiosks were used for approximately 8 outings for a successful fall club membership drive.

Digital Library

The committee continued to enhance the OFNC's 'digital photo library and catalogue' scanning many of the slides from the slide library.

OFNC Nature Photography Contest

The Committee initiated a 2nd Annual Photography Contest (to run until September 2007) to encourage discovery of nature and further enhance the club's digital library. This contest is open to the general public.

Brochures

The committee continued to distribute the club brochure to area libraries and nature shops.

Club T-Shirt

Committee member Laura Penney designed a beautiful new OFNC T-Shirt and 300 shirts of various sizes were printed for sale.

GILLIAN MARSTON
Chair, Education & Publicity Committee

Excursions and Lectures Committee

This Committee took great pleasure in arranging (and attending) 36 trips, ten monthly meetings (including the ABM) and the Soirée. We had one bus trip to Montreal (Biodome, etc.); the rest were by car pool leaving from either Lincoln Fields or Elmvale Acres. The monthly meetings from September to December were held at the Neatby Building, Agriculture and Agri-food Canada because the CMN was undergoing renovations. These facilities were quite satisfactory. We had 11 birding trips, 2 insect trips, 1 on plants, 1 on fungi, lichens and ferns, 1 on glaciation and the landscape, and 17 general natural history outings. Trips a little further afield (wetlands near Spencerville and snowshoeing in Algonquin Park) were very popular as were two mid-week events (early morning birding and a museum visit).

The Soirée was well-attended because many former Macoun Club members were specially invited.

FENJA BRODO
Chair, Excursions & Lectures Committee

OFNC Executive Committee

The Executive Committee met once to review issues and consider strategic alternatives during 2006.

MICHAEL MURPHY
Chair, Executive Committee

Finance Committee

The Finance Committee met three times during the year. Highlights include:

The Committee recommended, effective for the 2006-07 year, an increase in individual membership from $28.00 to $33.00 and an increase in family membership from $30.00 to $36.00. A subscription to CFN will be similarly increased.

Finance Committee considered a request from the Ottawa Riverkeepers to fund the printing of the first River Report for the Ottawa River. The report supports the objectives of the Club. Council agreed with the recommendation to provide $10,000 from the Groh bequest for this purpose.

A proposed budget for 2006-07 was developed and submitted to Council. A deficit of $13,400 was forecast for the Club and a deficit of $8,000 was forecast for the *Canadian Field-Naturalist*. Finance Committee emphasized the need to raise additional funds since these deficits cannot continue.

ANN MACKENZIE
Chair, Finance Committee

Fletcher Wildlife Garden

The Fletcher Wildlife Garden has completed another successful year. Wildlife continues to make good use of it and several new species have been added to our lists. The Management Committee met eleven times during the year. The 12th meeting was an end of season volunteer appreciation attended by about 30 people.

On March 24th in Toronto FWG was presented with the Ontario Association of Landscape Architects' 2006 Certificate of Merit for Service to the Environment. This award was later featured at Agriculture and Agri-food Canada's volunteer appreciation event.

Volunteers contributed over 3000 hours, mainly on Friday and Sunday mornings or Wednesday evenings. This year in addition to work in the Backyard Garden there was extensive work to extend the Butterfly Meadow, with plantings of native perennials, trees and shrubs. Sections of split rail fencing and rock piles were also added. Flowers were planted in the Ash Woods by a Pathfinder (Girl Guides) group.

Our struggle with invasive species continues. Garlic mustard and buckthorn are fairly well under control, but not eliminated. Pale swallow-wort is more difficult to remove without damage to other plants. We are reduced to measures to prevent overgrowth and seed production in critical areas while we wait for biocontrol methods. A group of Ontario Stewardship Rangers and a group from Nepean High School visited to help with invasive control.

About 30 people attended our International Migratory Bird Day event in May and a similar number visited during the Central Experimental Farm Open House. Our display was at the Wildlife Festival and at Agriculture and Agri-food Canada for Environment Week. FWG was used for 4 OFNC excursions, and by one school class and a field trip for the Monarch Teachers' Network. Talks were presented to three outside groups.

Our fund-raising this year proved quite successful. The annual Plant Sale raised almost $3000. A grant from Human Resources and Skills Development Canada allowed us to employ a summer student for 10 weeks. She operated the Interpretation Centre, worked with visitors, prepared materials for displays and the Backyard Garden and made and recorded wildlife observations. Once a week she provided activities for a children's day camp from Carleton University. The TD Friends of the Environment Foundation funded the printing of a brochure and contributed to remodeling of the map sign by the parking area. At third grant from the Evergreen Foundation. in the form of a gift card for Home Depot, also helped with the sign and the Butterfly Meadow work.

Our web site (http://www.ofnc.ca/fletcher.php) has been improved with news of recent events and observations and a plant database.

DAVID HOBDEN
Chair, Fletcher Wildlife Garden Committee

Macoun Club Committee

The Committee met once, and otherwise coordinated the weekly and monthly planning by telephone and e-mail. Committee members supervised or gave presentations at 17 indoor meetings, and led 16 field trips.

For the second year running, the Macoun Club was without a high-school aged group (our Seniors). Almost all recruiting efforts now are focused on building a strong Junior group that, growing up in Macoun Club, should eventually re-establish the Seniors.

As the year drew to a close, we were advised by our co-sponsor, the Canadian Museum of Nature, that it would not be able to provide any meeting space during the remainder of the renovation period at the Victoria Memorial Museum Building (to 2009). The Museum has, however, warehoused the Macoun Club's collections and file cabinets, and expressed a willingness to assist in other ways.

Issue No. 60 of the Macoun Club's annual publication, *The Little Bear*, was put together by a young member and his family. It was distributed to members at the annual party in June.

ROBERT E. LEE
Chair, Macoun Field Club

Membership Committee

The distribution of the membership for 2006 is shown in the table (on next page), with the corresponding numbers for 2005 in brackets. "Others" represent, for the greatest part, affiliate organizations that receive complimentary copies of the Club's publications. Local membership (within 50 km of Parliament Hill) was 684 and 680 in 2005 and 2006, respectively. The reduction of 11 in total membership is a continuation of this trend in recent years and presents a challenge to the Club.

This year, the Club lost a long time member, John Cameron, who joined the Club in 1970. In particular, his contribution to the Education and Publicity Committee must be acknowledged.

HENRY STEGER
Chair, Membership Committee

Publications Committee

The Publications Committee met three times in 2006, one of these in conjunction with the Finance Committee.

Four issues of *The Canadian Field-Naturalist* were published in 2006: Volume 118(4) and Volume 119(1,2,3). These

	CANADIAN		USA		OTHER		TOTAL	
Individual	401	(408)	16	(18)	5	(5)	422	(431)
Family	332	(331)	1	(2)	2	(1)	335	(334)
Sustaining	9	(11)	0	(0)	0	(0)	9	(11)
T and L	6	(6)	0	(0)	0	(0)	6	(6)
Honorary	25	(26)	0	(0)	0	(0)	25	(26)
Life	42	(41)	6	(6)	1	(1)	49	(48)
Other	30	(31)	1	(1)	1	(1)	32	(33)
Total	845	(854)	24	(27)	9	(8)	878	(889)

four issues contained 666 pages; 60 articles; 28 notes; 56 book reviews; 115 new titles; 2 commemorative tributes; 20 pages of News and Comments; 4 pages of miscellany; and a 28 page index. No funds were drawn from the Manning Memorial Fund. Re: electronic publishing, the OFNC web-site now carries the table of contents; all of the abstracts of articles and notes; and the News and Comments from each issue, as well as the annual indices. The committee feels that this is as far as we should go in this regard for the foreseeable future. Publishing costs are still a matter of concern.

Volume 40 of *Trail & Landscape* was published in four issues containing 226 pages. Issue 4 contains the 5-year index for Volumes 36 – 40. Preparation of the second 20-year index is underway. Costs have risen because of the loss of the Canadian Heritage subsidy for mailing.

Respectfully submitted,

RONALD E. BEDFORD
Chairman, Publications Committee

Auditor's Report

To The Members of THE OTTAWA FIELD NATURALISTS' CLUB

I have audited the statement of financial position of THE OTTAWA FIELD-NATURALISTS' CLUB as at September 30, 2006, the statement of changes in net assets, the statement of operations, and the statement of cash flows for the year then ended. These financial statements are the responsibility of the organization's management. My responsibility is to express an opinion on these financial statements based on my audit.

Except as explained in the following paragraph, I conducted my audit in accordance with Canadian generally accepted auditing standards. Those standards require that I plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, THE OTTAWA FIELD-NATURALISTS' CLUB derives some of its revenue from donations and fund-raising activities. These revenues are not readily susceptible to complete audit verification. Accordingly, my verification of these revenues was limited to the amounts recorded in the records of THE OTTAWA FIELD-NATURALISTS' CLUB, and I was not able to determine whether any adjustments to the recorded amounts might be necessary.

In my opinion, except for the effects of adjustments, if any, which I might have determined to be necessary had I been able to satisfy myself concerning the completeness of the revenue referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the organization as at September 30, 2006, and the results of its operations and cash flows for the year then ended in accordance with Canadian generally accepted accounting principles.

JANET M. GEHR
C.A., Licensed Public Accountant

North Gower, Ontario
6 January 2007

The Ottawa Field-Naturalists' Club
Balance Sheet
September 30, 2006

	2006	2005
ASSETS		
CURRENT		
Cash	$26,480	$27,819
Investment certificates (Note 1)	15,145	29,401
Marketable securities (Note 2)	31,187	0
Accounts receivable	31,491	21,837
Prepaid expenses	0	1,000
	$104,303	80,057
LAND – ALFRED BOG	3,348	3,348
Marketable securities (Note 2)	315,501	338,834
	$423,152	$422,239
LIABILITIES AND FUND BALANCES		
CURRENT		
Accounts payable and accrued liabilities	$2,500	$3,500
Deferred revenue	11,688	12,049
	14,188	15,549
LIFE MEMBERSHIPS	14,079	14,079
NET ASSETS		
Unrestricted	145,238	147,823
Club reserve	100,000	100,000
Manning principal	100,000	100,000
Manning interest - OFNC	1,948	1,014
- CFN	24,225	20,490
Seedathon	329	810
Anne Hanes memorial	788	870
de Kiriline-Lawrence	17,174	16,619
Macoun Baillie Birdathon	1,253	1,180
Alfred Bog	3,930	3,805
At cost assessed value $19,100	394,885	392,611
	$423,152	$ 422,239

The Ottawa Field-Naturalists' Club
Statement of Operations
For the Year Ended September 30, 2006

	2006	2005
REVENUE		
Memberships	$ 13,490	$ 13,635
Trail and Landscape	146	220
Interest	2,730	2,129
GST rebate	1,005	720
Other	623	622
	17,994	17,326
OPERATING EXPENSES		
Affiliation fees	$625	652
Computer	841	1,846
Membership	836	1,363
Office Assistant	1,275	1,000
Telephone	1,782	1,733
Insurance	725	725
Audit	2,000	2,500
GST	1,460	1,755
Other	946	1,072
	10,490	12,646
CLUB ACTIVITY EXPENSES		
Awards	$232	390
Birds	385	618
Education and Publicity	2,627	1,149
Excursions and Lectures	832	(1,805)
Macoun Field Club	1,139	466
Origins and History of OFNC	0	3,800
Soiree	46	228
Trail and Landscape	10,014	8,887
Fletcher Wildlife Garden (Note 4)	2,321	3,667
Other	323	0
	17,919	17,400
SURPLUS (DEFICIT) OF REVENUE OVER EXPENSES	$ (10,415)	$ (12,720)

The Ottawa Field-Naturalists' Club
Canadian Field-Naturalist — Statement of Operations
For the Year Ended September 30, 2006

	2006	2005
REVENUE		
Memberships	$ 9,311	$ 9,090
Subscriptions	24,314	25,135
Reprints	5,267	6,578
Publication charges	27,470	23,270
Interest and exchange	10,829	9,824
GST rebate	1,542	2,503
Other	1,299	1,231
	80,032	77,631
EXPENSES		
Publishing	57,735	20,777
Reprints	3,832	4,658
Circulation	9,678	8,532
Editing	1,856	2,394
Office Assistant	5,000	5,000
Honoraria	9,000	9,000
GST	4,870	2,693
Other	24	191
	91,995	53,245
EXCESS EXPENSES OVER REVENUE	$ (11,963)	$ 24,386

The Ottawa Field-Naturalists' Club Notes to the Financial Statements
September 30, 2006

1. Cash

	2006	2005
Chequing	$ 1,945	$ 16,144
Savings	20,630	6,963
Nesbitt Burns	919	459
Fletcher Wildlife Garden	2,986	4,253
	$ 26,480	$ 27,819

Investment Certificates:	Maturity Value	Maturity Date	Yield	Book Value
	$ 15,145	05/01/06	3.25%	$ 15,145

2. Marketable Securities

(Market Value $343,241)	Maturity Value	Maturity Date	Yield	Book Value
Province of Newfoundland Coupon	$ 44,782	10/17/11	4.525%	$ 36,400
Province of Ontario Coupon	15,376	12/02/12	4.591%	11,703
Province of Manitoba Coupon	45,740	09/05/13	4.694%	33,612
Res CIBC Int BB6	70,827	10/31/14	4.144%	51,188
CMHC Global Debs	52,000	12/01/06	5.250%	53,538
Province of Ontario Bond	30,000	09/12/07	6.125%	31,187
Province of Newfoundland Bond	20,000	10/07/08	6.263%	20,538
Government of Canada Coupon	30,167	12/01/09	5.605%	24,944
Province of New Brunswick Bond	60,000	12/03/15	3.965%	62,510
Province of New Brunswick Bond	20,000	06/15/10	6.231%	21,068
				$346,688

3. Capital Assets

Equipment at a cost of $16,748 is fully amortized.

4. Fletcher Wildlife Garden

	2006	2005
REVENUE		
Human Resources and Skills Dev. Canada	$ 2,500	$ 296
TD Friends of the Environment Fund	1,500	0
Taverner Cup	67	96
Sales	3,083	3,463
GST	221	155
Donations	480	200
	7,851	4,210
EXPENSES		
Program	3,235	614
Backyard	2,167	2,142
Habitats	2,584	2,213
Interpretation centre	32	223
Administration	409	706
Publications	1,295	1,479
GST	356	388
Library	94	112
	10,172	7,877
	$(2,321)	$(3,667)

5. Statement of Changes in Net Assets

a) Unrestricted other revenue includes the balance of a bequest of $23,717 from the Estate of Mildred Groh.

b) Unristricted other expenses: a donation to enable the publication of the River Keepers' River Report.

c) Seedathon Expenses: birdseed for club feeders, $1314.

6. Publication Liability

An annual membership fee or subscription entitles the member/subscriber to four issues of *The Canadian Field-Naturalist* based on a calander year. As the year end of the Club is September 30, the Club incurs a liability for publishing the fourth issue of each publication.

At this time, however, the publication of *The Canadian Field-Naturalist* is running late. At September 30, 2006, the Club owes members/subscribers issue number 3 and 4 of 2005 and three issues of 2006. Although most of the work preparing these publications is done by volunteers, the Club must pay for printing and mailing. Based upon recent costs, it is estimated that the Club has a liability of $68,000 for the outstanding issues. This amount will be reduced by page charges to the authors in the amount of 40% of the printing costs.

The Ottawa Field-Naturalists' Club Statement of Changes in Net Assets
For the Year Ended September 30, 2006 (see note 5 for footnotes)

Net Assets	Beginning Balance	Excess Expenses CFN	Excess Expenses OFNC	Other Revenue	Other Expenses	Ending Balance
Unrestricted	$147,823	$(11,963)	$(10,415)	$29,793 a)	$(10,000) b)	$145,238
Club reserve	100,000	0	0	0	0	100,000
Manning Principal	100,000	0	0	0	0	100,000
Manning - CFN	20,490	0	0	3,735	0	24,225
Manning - OFNC	1,014	0	0	934	0	1,948
Seedathon	810	0	0	833	(1,314) c)	329
Anne Hanes Memorial	870	0	0	0	(82)	788
de Kiriline-Lawrence	16,619	0	0	555	0	17,174
Macoun Baillie Birdathon	1,180	0	0	146	(73)	1,253
Alfred Bog	3,805	0	0	125	0	3,930
	$392,611	$(11,963)	$(10,415)	$36,121	$(11,469)	$394,885

The Ottawa Field-Naturalists' Club Summary of Significant Accounting Policies

September 30, 2006

1 Nature of Business

The organization is non-profit and incorporated under the laws of Ontario (1884). The organization promotes the appreciation, preservation, and conservation of Canada's natural heritage. It encourages investigation and publishes the results of the research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with other organizations engaging in preserving, maintaining or restoring environments of high quality for living things.

2. Financial Instruments

The organization's financial instruments consist of cash, accounts receivable, marketable securities, and accounts payable. Unless otherwise noted, it is the management's opinion that the organization is not exposed to significant interest, currency, or credit risks arising from these financial instruments. The fair value of these instruments approximate their carrying values, unless otherwise noted.

3. Capital Assets

Capital assets in excess of $4,000 cost are recorded as assets at cost and amortized on a straight-line basis. These assets have been fully amortized.

4. Revenue Recognition

Revenue is recognized when earned for donations and fund-raising when received.

5. Foreign Currency

Transactions during the year in U.S. dollars have been converted in the accounts to Canadian dollars at the exchange rate effective at the date of the transaction. All monetary assets in U.S. dollars at year end have been converted to Canadian dollars at the rate effective on Sept. 30, 2006.

Gains or losses resulting therefrom are included in revenue or expenses.

Advice for Contributors to *The Canadian Field-Naturalist*

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. The journal also publishes natural history news and comment items if judged by the Editor to be of interest to readers and subscribers, and book reviews. Please correspond with the Book Review Editor concerning suitability of manuscripts for this section. For further information consult: A Publication Policy for the Ottawa Field-Naturalists' Club, 1983. *The Canadian Field-Naturalist* 97(2): 231-234. Potential contributors who are neither members of *The Ottawa Field-Naturalists' Club* nor subscribers to *The Canadian Field-Naturalist* are encouraged to support the journal by becoming either members or subscribers.

Manuscripts

Please submit by post **to the Editor,** in either English or French, **three** complete manuscripts **written in the journal style.** Manuscripts may also be submitted (one copy) by e-mail. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. All authors should have read and approved it. Institutional or contract approval for the publication of the data must have been obtained by the authors. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals. The place where voucher specimens have been deposited, and their catalogue numbers, should be given. Latitude and longitude should be included for all individual localities where collections or observations have been made.

Manuscripts should be printed on standard-size paper, **doublespaced throughout,** generous margins to allow for copy marking, and **each page numbered.** For Articles and Notes provide a bibliographic (citation) strip, an abstract, and a list of key words. Generally, words should not be abbreviated but use SI symbols for units of measure. The names of authors of scientific names may be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. "Standard" common names (with initial letters capitalized) should be used at least once for all species of higher animals and plants; all should also be identified by scientific name.

The names of journals in the Literature Cited should be written out in full. Unpublished reports and web documents should not be cited here but placed in a separate Documents Cited section. List the captions for figures numbered in arabic numerals and typed together on a separate page. Present the tables each titled, numbered consecutively in arabic numerals, and placed on a separate page. Mark in the margin of the text the places for the figures and tables.

Check recent issues (particularly Literature Cited) for journal format. Either "Canadian" or "American" spellings are acceptable in English but should be consistent within one manuscript. **The Oxford English Dictionary, Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations

Photographs should have a glossy finish and show sharp contrasts. Electronic versions should be high resolution. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Photographic reproduction of line drawings should be **no larger than a standard page.** Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

Reviewing Policy

Manuscripts submitted to *The Canadian Field-Naturalist* are normally sent for evaluation to an Associate Editor (who reviews it or asks another qualified person to do so), and at least one other reviewer, who is a specialist in the field, chosen by the Editor. Authors are encouraged to suggest names of suitable referees. Reviewers are asked to give a general appraisal of the manuscript followed by specific comments and constructive recommendations. Almost all manuscripts accepted for publication have undergone revision—sometimes extensive revision and reappraisal. **The Editor makes the final decision** on whether a manuscript is acceptable for publication, and in so doing aims to maintain the scientific quality, content, overall high standards and consistency of style, of the journal.

Special Charges — Please take note

Authors **must share in the cost of publication** by paying $90 for each page, plus $30 for each illustration (any size up to a full page), and up to $90 per page for tables (depending on size). Authors may also be charged for their changes in proofs. Reproduction of color photos is extremely expensive; price quotations may be obtained from the Editor.

Limited journal funds are available to help offset publication charges to authors without grants or institutional support. Requests for financial assistance should be made to the Editor when the manuscript is submitted.

Reprints

An order form for the purchase of reprints or pdf will accompany the galley proofs sent to the authors. Invoices for publication costs will be sent when the submission is published.

FRANCIS R. COOK, Editor
RR 3 North Augusta, Ontario K0G IR0 Canada

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COVER: Bufflehead, *Bucephala albeola*. Photographed at Shoal Harbour Migratory Bird sanctuary, southeastern Vancouver Island by Suzanne Huot. See articles by James K. Findley pages 370-374 and 375-378.

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The Canadian Field-Naturalist

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Moose, *Alces alces,* Winter Browse Use in Central Labrador

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Newbury, Tina L., Neal P. P. Simon, and Tony E. Chubbs. 2007. Moose, *Alces alces*, winter browse use in central Labrador. Canadian Field-Naturalist 121(4): 359-363.

To determine the effect of forestry practices on the availability of winter Moose forage, we recorded Moose browse along four 250 m transects in each of five forest regeneration ages. Browse use was greater on 20- and 30-year-old regenerating stands as compared with recently clearcut stands (5 and 10 years old) or mature forest (> 150 years old). Willow (*Salix* sp.) followed by White Birch (*Betula papyrifera*) had the highest proportion of browsing by Moose.

Key Words: Moose, *Alces alces,* browse, logging, Labrador.

Since the early 1950s, Moose (*Alces alces*) have expanded into Labrador, independent of introductions on the Labrador coast (Mercer and Kitchen 1969; Dalton 1986*; Chubbs and Schaefer 1997). Conversions of mature forests into early and mid-successional seres are partly responsible for Moose increases in most of North America (Bergerud and Manuel 1968; Collins and Helm 1997; Rempel et al. 1997) since Moose tend to be associated with mid-successional forests (Bergerud and Manuel 1968; Telfer 1974; Pierce and Peek 1984; Collins and Helm 1997; McCracken et al. 1997; McLaren et al. 2000). It is unlikely that the first expansion of Moose into Labrador resulted from forest cutting; most cutting is limited to discrete areas isolated from the historical distribution of Moose in eastern Canada and logging largely began in the late 1960s (FMDPT 2003*) after Moose had become established in Labrador (Chubbs and Schaefer 1997). However, anticipated increases in logging in Labrador (FMDPT 2003*) will likely increase the amount of forest in successional stages favorable to Moose, possibly increasing Moose densities.

Moose favor areas of highest forest productivity, preferring 5- to 15-year-old regenerating stands where vegetation reaches heights of 3 m and is thus available above snow (Dodds 1960; Bergerud and Manuel 1968; Telfer 1974; McLaren et al. 2000). The mosaic of food and cover produced by logging can benefit Moose. High quality food is important for storing winter fat and provides females with the nutrients required for rearing young (Leptich and Gilbert 1989), while thermal cover is important for energy conservation (Schwab and Pitt 1991). Early and mid-aged clearcuts are favorable to Moose relative to forested stands in part due to more total browse (Telfer 1974; Schwab et al. 1987; Collins and Helm 1997) and because wind exposure reduces snow depths (Schwab et al. 1987). Early regenerating and pre-commercially thinned Balsam Fir (*Abies balsamea*) stands may also attract Moose, depending on site type (Thompson et al. 1992; McLaren et al. 2000).

There is considerable geographical and seasonal variation in Moose diets, yet coarse patterns exist (Peek 1974). In boreal forests during winter, Moose make high use of White Birch (*Betula papyrifera*), Mountain Maple (*Acer spicatum*), and Balsam Fir saplings, willow (*Salix* sp.), and with lesser amounts of Red-osier Dogwood (*Cornus stolonifera*), Pin Cherry (*Prunus pennsylvanica*), Mountain Ash (*Sorbus americana*), and *Viburnum* spp. (Dodds 1960; Bergerud and Manuel 1968; Peek 1974; Proulx and Joyal 1981; McLaren et al. 2000). Leaves and annual growth stems of the above species are dominant spring and summer forage. Additional summer foods include plants such as Yellow Water Lily (*Nuphar microphyllum*), horsetail (*Equisetum* sp.), fireweed (*Epilobium* spp), and sedges (*Carex* spp.) (Dodds 1960; Irwin 1985).

To determine the effects of forest harvesting on Moose browse, we documented Moose browsing across regenerating clearcuts of four ages (5 to 30 years old) and mature, uncut forests.

Study Area

The study was conducted from 28 June to 10 August 2004 within 40 km of Happy Valley-Goose Bay (53°19'N, 60°25'W), Newfoundland and Labrador, Canada (Figure 1). Sites were located in the High Boreal Forest Ecoregion of Labrador (Meades 1990*); this region contains the most productive forests for commercial timber in Labrador (Wilton1959; Lopoukhine et al. 1975). The moderately rolling terrain is dominated by Black Spruce (*Picea mariana*) and Feather Moss (*Pleurozium schreberi*) forest at the higher elevations and Balsam Fir/Black Spruce/White Birch forest at slightly lower elevations (Lopoukhine et al. 1975). This area experiences a mean annual temperature of -0.5°C (mean monthly range: -18.1 to 15.4°C) and precipitation amounts of 949 mm, half of which falls as snow (Environment Canada Climate Normals: http://www.msc-smc.ec.gc.ca; viewed 27 September 2004). Snow remains on the ground from October through June. Approximately 12% of this study area was commercially harvested from the late 1960s to 2004 (FMDPT 2003*). The area is accessible to hunters and the most recent density estimates reported 0.168 Moose/km^2 in 1994 (Chubbs and Schaefer 1997).

Methods

We established twenty 250 m-long transects in different stands, with four transects representing four clearcut ages (approximately 30, 20, 10, and <5 years following cutting) and uncut mature (>150 years old) forest. We selected stands ranging from 30 to 700 ha and those within the same age group were chosen as far apart as possible (≥ 700 m) while still being accessible. Prior to harvest, stands were dominated by Black Spruce and classified as commercial, i.e., supporting > 100 m^3 of timber per ha with canopy height ranging from 9.5 to 18.5 m tall and crown closure ranging from 50 to 75%. Our mature forest transects reflected this variation and all sites had regenerated. Transects in harvested stands started at commercial mature forest edges and were oriented to avoid all other stand edges, roads and patches of remnant forest.

Transects consisted of evenly spaced plots at 50 m intervals. Each plot consisted of five 4.5 m^2 circular subplots: one central and the remaining four in the cardinal directions 10 m from the centre. Within each subplot, plant species, number of stems and occurrence of Moose browsing were recorded.

Results

Most browsing occurred in the 20- and 30-year-old stands, with willow being the most proportionately, 0.50 and 0.80, respectively, browsed species. Willow accounted for only 0.8% of total stems but represented 16.5% of the total stems browsed across 20- and 30-year-old stands. The second most proportionately browsed species was White Birch (0.33 and 0.48 in 20- and 30-year-old stands, respectively). Considerably smaller proportions of Mountain Alder (*Alnus crispa*), Balsam Fir and Black Spruce were browsed. There was virtually no browsing in clearcuts < 15 years old and forests > 150 years old.

Discussion

Throughout their range and between seasons, species browsed by Moose varies, but tends to be dominated by willow when available (Peek 1974; McCracken et al. 1997; Collins 1999). Similarly, we found that willow was the most proportionately browsed species in Labrador. Our second most proportionately browsed species, White Birch, was also a prominent Moose browse throughout Canada (Dodds 1960; Peek 1974). However, in contrast to other regions (Dodds 1960; Bergerud and Manuel 1968; Thompson et al. 1992) proportionately little Balsam Fir was browsed in our study. Balsam Fir is generally a winter food (Dodds 1960) and may be selected only when deciduous species are unavailable or where Moose densities are high (McLaren et al. 2000). Moose are reported absent from apparently suitable habitat in Labrador and are possibly limited by Wolf (*Canus lupus*) predation, illegal hunting, and snow depths (Trimper et al. 1996). Although snow depth could limit food supply (Schwab et al. 1987), it also increases expended energy (Schwab and Pitt 1991). Illegal hunting, Wolf predation and energy costs of snow depth may depress Moose populations enough that they can forage on the preferred willow and White Birch rather than resorting to Balsam Fir.

Our finding of more Moose browsing in 20- and 30-year-old stands is similar to other studies that found greater amounts of browse and Moose densities in regenerating clearcuts (Telfer 1974; Schwab et al. 1987; Leptich and Gilbert 1989; Collins and Helm 1997; Thompson et al. 1999; McLaren et al. 2000). However, our peaks in Moose browsing occurred 10 – 15 years later than suggested by Dodds (1960) and Telfer (1974), likely due to the slower regeneration rate in our study area than in more southerly Moose ranges. Our results suggest that increases in forest cutting may increase Moose densities by enhancing browse production. However, the lack of browsing on less preferred species (e.g., Balsam Fir) indicates Moose are probably not limited by winter browse and therefore Moose may not increase as rapidly as in other areas. Although we found few browsed stems outside 20 – 30 year old clearcuts, Moose may use these areas to graze on herbs during summer and fall. Browse surveys alone may not be enough to quantify Moose diets – fecal and rumen analyses and foraging observations would help to better determine seasonal Moose forage preferences (McCracken et al. 1997).

Increased Moose densities resulting from logging may enhance recreational and sustenance activities; e.g., viewing and hunting. However, increased Moose densities are believed to increase Woodland Caribou

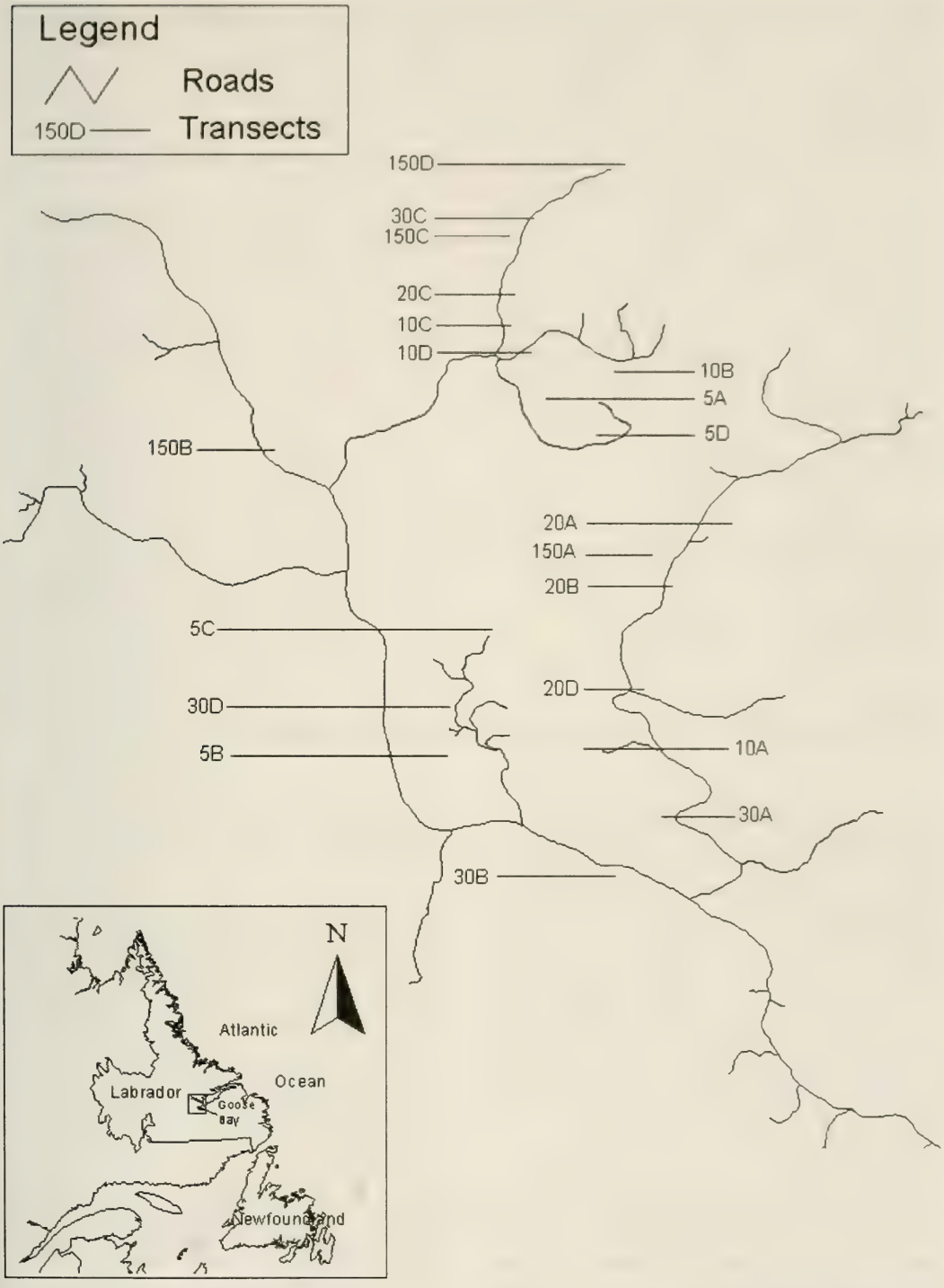

FIGURE 1. Study area showing the locations of each of the four (A, B, C and D) transect locations for each clearcut age (5, 10, 20, 30, and 150 years).

TABLE 1. Proportion of plant stems browsed by Moose and standard error according to clearcut age (n = 100 per age).

Plant species	Number of stems	Browsed stems	Proportion	Standard error
5 years				
Abies balsamea	302	0	–	–
Picea mariana	623	0	–	–
Alnus crispa	0	0	–	–
Betula papyrifera	3	0	–	–
Salix spp.	0	0	–	–
10 years				
Abies balsamea	165	1	0.006	0.006
Picea mariana	657	0	–	–
Alnus crispa	0	0	–	–
Betula papyrifera	7	0	–	–
Salix spp.	8	0	–	–
20 years				
Abies balsamea	912	6	0.007	0.003
Picea mariana	1429	2	0.001	0.001
Alnus crispa	118	11	0.093	0.013
Betula papyrifera	45	15	0.333	0.071
Salix spp.	26	13	0.500	0.100
30 years				
Abies balsamea	627	4	0.006	0.003
Picea mariana	1111	2	0.002	0.001
Alnus crispa	0	0	–	–
Viburnum edule	0	0	–	–
Betula papyrifera	129	63	0.488	0.044
Salix spp.	10	8	0.800	0.133
> 150 years				
Abies balsamea	345	0	–	–
Picea mariana	930	0	–	–
Alnus crispa	0	0	–	–
Betula papyrifera	1	0	–	–
Salix spp.	7	0	–	–

(*Rangifer tarandus*) mortality possibly thorough an influx of large predators; e.g., Wolves (Bergerud and Elliot 1986; Klein 1991; Seip 1992; Schaefer et al. 1999) and Black Bears, *Ursus americanus* (Mahoney and Virgl 2003). Boreal populations of Woodland Caribou are threatened in Labrador (Schmelzer et al. 2004*), so it may be desirable to reduce Moose forage, notably White Birch and willow, on regenerating clearcuts. Our results indicate that accelerating the passage of clearcuts through earlier successional stages by aggressive Black Spruce planting and targeting Moose forage in pre-commercial thins would have the greatest negative impact on Moose winter forage.

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Movements of Transient Coyotes, *Canis latrans,* in Urbanized Eastern Massachusetts

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Way, Jonathan G. 2007. Movements of transient Coyotes, *Canis latrans*, in urbanized eastern Massachusetts. Canadian Field-Naturalist 121(4): 364-369.

I document the movements of five transient (or nomadic) eastern Coyotes (*Canis latrans*) in heavily urbanized eastern Massachusetts. Linear movements from capture location to end location varied from 23.0 to 100.5 km and averaged 63.8 ± 52.0 km for two females and 38.7 ± 17.2 km for three males ($t = 0.657$, $df = 1.15$, $P = 0.618$). Transients ranged in age between 1-2 yr old. There was no relationship between Coyote body weight and dispersal distances ($r = 0.389$, $P = 0.518$). Coyotes travel long distances even in human-dominated areas, allowing transients to find vacant territories. Because of the ability of Coyotes to colonize and recolonize areas, I recommend that Coyote management efforts focus more on educating the public about actual Coyote behavior and their life history needs than on killing them.

Key Words: Eastern Coyote, *Canis latrans*, dispersal, human-dominated landscapes, movements, suburban, transient, urbanized Massachusetts.

Coyotes (*Canis latrans*) typically live in packs consisting of a breeding pair, resident associates (helpers), and pups of the year (Gese et al. 1996; Way et al. 2002a). Coyote packs defend a territory while nomadic or transient Coyotes, usually young, but sometimes old individuals (see Way 2007a), travel among a matrix of territories as they disperse from their natal range (Harrison 1992; Way et al. 2002a). Individual Wolves (*Canis lupus*) and Coyotes are known to disperse several hundred kilometers from their natal range (Fritts 1983; Carbyn and Paquet 1986; Gese and Mech 1991; Harrison 1992; Mech and Boitani 2003a), which facilitates recolonization of areas where control actions limit their numbers or where they are expanding their range (Parker 1995; Mech and Boitani 2003a).

Movements of dispersing transient Coyotes have been documented in rural/forested areas (Harrison 1992), agricultural landscapes (Person 1988), and in southern Canada (Carbyn and Paquet 1986). Coyotes have also been documented to travel across seemingly disparate areas, such as wide canals (Way 2002), islands (Thomas and Dibblee 1986), and on drifting pack ice (Chubbs and Phillips 2002). However, aside from one documented Coyote in urban/agricultural southern Canada (Rosatte 2002), there are no data on transient/ dispersing Coyote movements in urbanized areas. Documenting the movement of transient Coyotes in urbanized areas will give managers data on how Coyotes move in these landscapes compared to more rural environs (e.g., Harrison 1992; Gese et al. 1996). This could have practical implications. For example, if transient Coyotes do not move far in urbanized locales (because of the high amount of roads) then localized control efforts may be more successful in reducing Coyote numbers in those regions; conversely, if the opposite is true (i.e., Coyotes move similar distances in urban and rural areas), then control efforts would likely be less successful, unless targeting a specific individual(s). This paper, part of a larger ongoing study on Coyote ecology (Way et al. 2001; Way et al. 2002a; Way et al. 2004) in eastern Massachusetts, documents the movement of transient Coyotes in a heavily urbanized region.

Study Areas

This research took place in two urbanized locations: Cape Cod and the towns and cities north of Boston (Figure 1). Most research conducted on the heavily urban north edge of Boston (~100-150 km^2; 42.43°N, 71.06°W) took place in the cities of Revere (3089 people/km^2, housing density = 1318/km^2), Everett (4345 people/km^2, housing density = 1817/km^2), and Malden (4291 people/km^2, housing density = 1800/km^2) (U.S. Census Bureau 2000 estimates). The area is characterized by high-density housing with small woodland areas (including cemeteries) non-strategically situated in towns and cities. Coyotes were captured and spent most of their time in these wooded, green areas as the high-density housing areas were often fenced and provided nowhere for Coyotes to travel, except for main roads. Railroad tracks and holes in some of the fences provided small corridors between some of the green areas (Way and Eatough 2006).

Cape Cod research was conducted within Barnstable County, Cape Cod, Massachusetts (approximate study area 250 km^2), with a concentration in the town/city of Barnstable (although called a town, Barnstable is technically a city; 41.67°N, 70.28°W; land area = 155.5 km^2).

Human population density in the town/ city of Barnstable was 308 people/km^2 and housing density was 161/km^2, while the entire Barnstable County (3382 km^2) averaged 217 people/km^2 and 144 houses/km^2 (U.S. Census Bureau 2000 estimates). The town/ city of Barnstable has a distinct rural-urban gradient within its borders; the highest and lowest densities of people were found in urban Hyannis (556 people/km^2, housing units = 328/km^2) and rural West Barnstable (89/km^2, housing units = 39/km^2) (Cape Cod Commission 1998*). Road density, defined as centerline km of roadway per km^2, was 4.7 for the town of Barnstable and 4.0 for Barnstable County (Cape Cod Commission 1998*). Cape Cod is characterized by being residential as well as having numerous small (5-10 ha) and a few large (~1000 ha) conservation areas interspersed throughout. Most of the neighborhoods are not fenced, however, and Coyotes were readily able to travel through these areas to access various portions of their home range (Way et al. 2004). Coyote pack territories were roughly 30 km^2 and were non-overlapping, similar to more rural areas (Gese et al. 1996; Way et al. 2002a).

Methods

Coyotes were captured by box trap (Way et al. 2002b) then radio-collared or radio-implanted (juveniles – i.e., pups of the year) using Telonics, Inc. (Mesa, Arizona) transmitters, aged based on tooth wear (Bowen 1982; Landon et al. 1998), weighed, blood drawn (ca. 4 cc), then released. Transient (or nomadic) Coyotes were classified as Coyotes who had no discernable territory and nomadically moved throughout the study areas, including within resident collared Coyote home ranges. These Coyotes are typically classified as young Coyotes that are in the process of dispersing from their natal pack (Way et al. 2002a).

Tracking protocols were described by Way et al. (2002a) and Way et al. (2004). Portable receivers (Custom Electronics, Urbana, Illinois, USA) and hand-held 3-element Yagi antennas were used to radio-track Coyotes both on foot and from a vehicle. Due to the highly developed landscape with many roads, I mostly radio-tracked in a vehicle as Coyotes did not react negatively to them as much as they did to people (e.g., by running away; Way 2007a; J. Way, unpublished data); occasionally I approached radio-collared Coyotes as closely as possible on foot without disturbing them. I used binoculars and video-cameras when observing Coyotes, and city street lights, nightscopes and occasionally headlights when following Coyotes at night with a vehicle (Way et al. 2002a; Way et al. 2004). Due to funding constraints, I did not use airplanes to search for Coyotes that left our study areas; extended trips were made in vehicles to locate missing Coyotes but this was often unsuccessful. Instead, I relied on recovering Coyotes from sightings by the public (n = 1), opportunistically receiving radio-locations in new areas (n = 1), and recovering carcasses from human-related kills (i.e., road-kill or gunshot; n = 3) Transient movement distances were calculated from where they were first captured (if not on natal territory) or from their natal territories (if known) to their final location when they either settled (i.e., established a resident home range in a new area) or died.

I used an independent sample two-tailed t-test to detect differences between male and female dispersal. Levene's test was used to detect for equal variance between samples; a significant Levene's result indicated that equal variances were not assumed. I correlated Coyote dispersal distances with body weight using two-tailed bivariate Pearson Correlation Coefficients (SPSS Inc., Chicago, Illinois) tests. I set significance at < 0.05.

Results and Discussion

I documented the movement of five transient Coyotes: one from north Boston and four from Cape Cod (Figure 2). Upon release, all Coyotes appeared to be in the process of dispersal as their movements were nomadic. Movements from capture to final location varied from 23.0 to 100.5 km and averaged 63.8 ± 52.0 km for two females and 38.7 ± 17.2 km for three males (Levene's Test = 0.030, t = 0.657, df = 1.15, P = 0.618). Although I had a low sample size, these movements were within the range of dispersal by transient Coyotes in more rural environments, with an average distance of 98 km for Coyotes in forested Maine (Harrison 1992), 16 – 152 km in rural Ontario (Kolenosky et al. 1978), 20 – 140 km in rural, agricultural Vermont (Person 1988), ≤ 30 km (depending on age class) in farmland-forested central Alberta (but up to 100 – 150 km; Nellis and Keith 1976), 12.7 – 17.9 km in the western United States (Robinson and Grand 1958), 35.7 km in Iowa (Andrews and Boggess 1978), 16 – 68 km (average = 48 km) in northern Minnesota (Berg and Chesness 1978), 36.4 km in New Mexico (Young and Jackson 1951), and 40.3 – 45.6 km (up to 161 km) in Wyoming (Young and Jackson 1951).

There was no difference between male and female transient movements and all were young (1 – 2 yr old) animals (Table 1), which is typical of when canids disperse (Harrison 1992; Mech and Boitani 2003a). Although I had a low sample size, it is noteworthy that a female exhibited the longest movements. Coyote #BN0402 traveled through nearly all of eastern Massachusetts, one of the most densely human populated areas in the country (U. S. Census Bureau 2000 estimates; Way 2007a). Additionally, female Coyote #0202 navigated across a 1 km canal to leave Cape Cod (Way 2002). However, caution should be taken with these low sample sizes and over-interpreting the results. For instance, as this paper went to press, Way (2008*) documented a yearling male Coyote that travelled 81.1 km, from the village of Centerville to

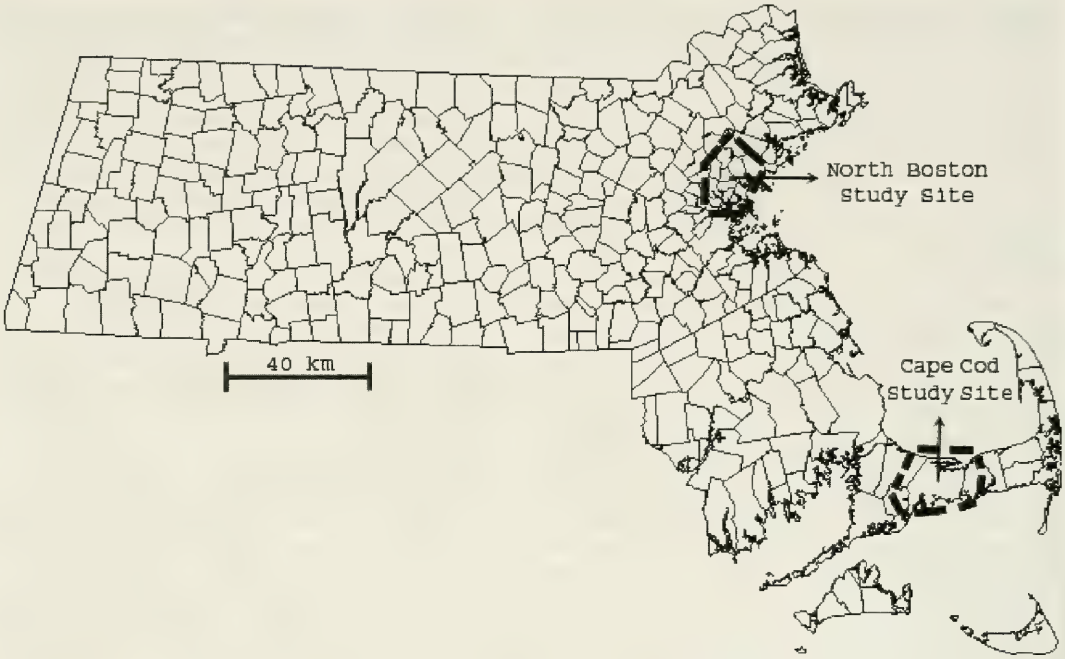

FIGURE 1. Map of the two Coyote study sites in eastern Massachusetts with polygons representing all of the towns in Massachusetts.

Hingham, Massachusetts, about 15 km southeast of Boston. This one animal's movement would have caused male Coyotes in this study to go from an average dispersal distance of 38.7 to 49.3 km. Thus, the male/female difference is not as important as the fact that this study is the first to document transient Coyote movements in urbanized locals.

Harrison (1992) found no sex specific statistical differences in Coyote dispersal in his Maine study, which might be expected for a monogamous species, but the maximal distance traveled (342 km) was by a female. Other studies corroborate these findings with individual females dispersing the farthest in their studies, such as 17.9 (vs. 12.7) km in the western United States (Robinson and Grand 1958), 323.2 km in Iowa (Andrews and Boggess 1978), 154 km in central Alberta (Nellis and Keith 1976), and 544 km from Riding Mountain National Park, Manitoba, to Saskatchewan, the furthest movement of a coyote on record (Carbyn and Paquet 1986). In fact, all long-distance movements were made by females except a male Coyote in Rosatte's (2002) study that moved 320 km in an agricultural region of southern Ontario (the most urban of the study sites after mine). However, most researchers claimed that these long-distance dispersals were rare.

The Boston Coyote likely exhibited a relatively straight-line dispersal through Boston and south to the edge of the Atlantic Ocean in southeastern Massachusetts where either the ocean stopped her movement and/or she paired up with a mate (Figure 2; Way

TABLE 1. Movements of transient (or nomadic) Coyotes in eastern Massachusetts

Coyote ID	Sex/Age (yr)	Start of dispersal[1]	Conclusion of dispersal[2]	Body weight (kg)	Minimum distance traveled (km)
#BN0402	Female (1)	April 2004	November 2004	13.6	100.5
#0301	Male (2)	December 2003	February 2005	18.5	57.1
#0401	Male (2)	February 2004	December 2005	14.5	23.0
#0202	Female (2)	January 2002	May 2002	19.1	27.0
#0205	Male (1.5)	March 2002	June 2003	15.2	36.1

[1]Represents when the animal was documented as a transient Coyote in the act of dispersal. Because all animals in this study were captured as transients and were likely off their natal ranges when captured, their respective capture location notes where I recorded their start of dispersal.

[2]Represents when an animal terminated nomadic movements or was recovered dead.

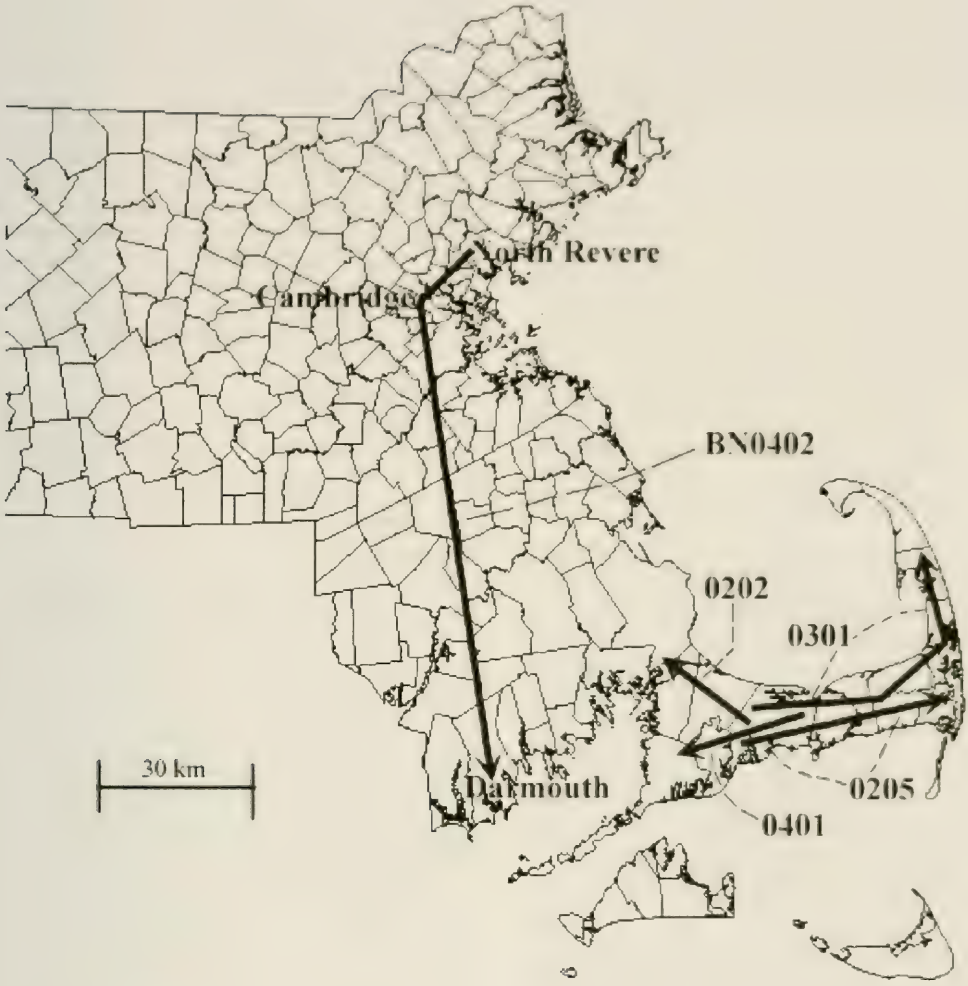

FIGURE 2. Movements of transient (or nomadic) Coyotes in eastern Massachusetts.

2007a). Because of the restricted movement paths possible for Coyotes dispersing on peninsular Cape Cod and because I did not sequentially track them when out of radio contact, it was difficult to assess movement direction. However, the four combined Coyotes were documented to travel throughout most of Cape Cod, radiating from the town of Barnstable study area (Figure 1), with two Coyotes each ultimately ending up both east and west of the Barnstable study site (Figure 2). Mech and Boitani (2003a: 15) noted that "In homogeneous habitat types, Wolves would probably disperse equally in all directions. However, no habitat type is homogeneous, and topography, Wolf density, and areas of human development no doubt play varying roles in steering dispersal, direction." Harrison (1992) noted that Coyotes in Maine often follow major rivers and that those water barriers often deflected and influenced Coyote dispersal, while Gese and Mech (1991) found that Wolves in Minnesota dispersed in relatively equal directions.

There was no relationship between Coyote body weight and distance traveled ($r = 0.389$, $P = 0.518$) with two relatively heavy and three light transient Coyotes (see Way 2007b for weight ranges), although caution should again be taken when inferring results because of low sample size. However, Gese and Mech (1991) also found no difference between wolf body weight and the age at dispersal or dispersal success. Yet Gese et al. (1996) discovered that Coyotes that dispersed from their natal pack in Yellowstone National

Park were often low ranking and had less access to food. One would presume that these Coyotes also weighted less than philopatric Coyotes.

Distances traveled by nomadic Coyotes in eastern Massachusetts represented minimum values because (1) most movements were made in a restricted, linear landscape (i.e., Cape Cod); (2) it was not known where all of the transients began dispersal (i.e., we did not capture them as juveniles within their natal ranges); and (3) it was not known if all localized (i.e., established or joined a pack) before death. If they were killed before settling then their potential dispersal distance may have been underestimated. Based on the time (months to one to two years) that I was not in contact with radio-collared Coyotes, I suspect that many Coyotes traveled the length of Cape Cod and only infrequently came into my study area. Coyotes can move long distances in short periods of time (Way et al. 2004) and I sporadically located these transients before they disappeared, presumably out of my study area.

The most accurate way to determine Coyote dispersal and subsequent transient movements is to radio-tag juveniles in their natal area and track how Coyotes disperse (e.g., Harrison 1992). However, dispersal is time intensive, expensive, and one of the most difficult of all population processes to document (Harrison 1992; Mech and Boitani 2003b). For example, I also radio-tagged nine additional juveniles (seven from Cape Cod; two from north of Boston) within their natal ranges but recovered no dispersal information on any of them because they either died on their natal territory (n = 5) or disappeared and were never relocated (n = 4). Thus, reporting transient Coyote movements in a range of landscapes, regardless of the sample size, is important.

In highly developed regions (e.g., eastern Massachusetts), it is likely that Coyotes travel across a gradient of urbanization (rural to urban) when dispersing. In other words, an "urban Coyote" would merely represent where that individual currently lives; that same individual could have originated from a much more rural location. For example, Coyote #BN0402 was captured in the process of dispersal in heavily urban north Boston (Revere, Massachusetts). She traveled southwest into heavily urban Cambridge, then vanished before being discovered in Dartmouth, Massachusetts (Way 2007a), a town that is rural-suburban with a large percentage of open space remaining (population density = 192/km^2, housing density = 71 km^2; U.S. Census Bureau 2000 estimates). She paired up with a male Coyote and produced pups in Dartmouth before dying of unknown causes in June 2005 in her recently established range.

Coyotes have colonized much of North America, including urbanized areas, south of the Arctic. While there may be times when individual(s) Coyotes may need to be removed from a population, widespread control efforts have never been successful at regulating Coyote numbers (Parker 1995), partly because of their well-documented dispersal and movement ability in a myriad of landscapes. The Coyote's persistence is nearly guaranteed throughout its range and the potential for (re)colonization of habitats ranging from rural to urban is very high. Therefore, I recommend that Coyote management efforts focus more on educating the public about actual Coyote behavior (e.g., Way 2005) and their life history needs than on killing them. As noted by Gompper (2002), the presence of Coyotes in northeastern North America and in cities, represents a natural range expansion of the species, not an exotic invasion, and the species is here to stay.

Acknowledgments

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The Punctual Bufflehead, *Bucephala albeola*: Autumn Arrivals in Shoal Harbour Sanctuary, Vancouver Island, in Relation to Freeze-up

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Finley, James K. 2007. The punctual Bufflehead, *Bucephala albeola*: Autumn arrivals in Shoal Harbour Sanctuary, Vancouver Island, in relation to freeze-up. Canadian Field-Naturalist 121(4): 370-374.

Buffleheads are punctual in their return to wintering grounds on the Pacific coast. First arrivals appeared in Shoal Harbour Migratory Bird Sanctuary, southeastern Vancouver Island, on the 288th day of the year on average (± S.D. 2.3; n = 10), that is, 15 October. This vanguard preceded the first peak influx by about 15–20 days, and a second influx by about 24–26 days. First arrivals usually appeared by mid-morning, and included singles (females on two occasions) and small flocks of up to eight. First arrivals may represent a photoperiodic threshold, whereas subsequent peak influxes represent climatic thresholds associated with freeze-up. The phenology of Bufflehead autumn migrations is a good proxy indicator of the advance of the zero degree isotherm, and thus of climatic variability. The timing of their autumn migrations does not appear to have changed in the last half of the twentieth century, consistent with evidence that freeze-up has not advanced. Monitoring of their migrations, in conjunction with shore-based observations of freeze-up, would validate one-dimensional thermodynamic models of freeze-up, and provide a more ecologically meaningful index of climate change, at minimal cost.

Key Words: Bufflehead, *Bucephala albeola*, phenological precision, autumn arrivals, freeze-up, climate change.

Synchronicity of life cycles with environmental cues is a key determinant of fitness, survivorship and reproductive success. With growing public interest in the impacts of global warming, there has been a resurgence in documenting phenological phenomema as indicators of environmental change. In Britain, for example, the average arrival dates of twenty migrants have advanced by eight days in the last several decades, raising concern that asynchrony in biological cycles with climatic change will increase stress on species, particularly the specialists (Cotton 2003).

The Bufflehead is a specialist, occupying a narrow niche, and is remarkable amongst the seaducks in that its population has remained stable over decades (Gauthier 1993). In his monograph on the species, Erskine (1972), advised that "If you would become familiar with a bird, you must live with it, day by day through the seasons, following the activities that fill its life and add up to the picture conjured up by its name. So it is with the bufflehead. ... People fortunate enough to live on the water's edge may watch buffleheads from their breakfast table ...". I'm one of the fortunate ones, being able to observe Buffleheads from my breakfast table, overlooking Shoal Harbour Migratory Bird Sanctuary, Vancouver Island, since 1984.

I've long been fascinated by the strange circumstances and climatic events that caused the "Great Bufflehead Crash" on the night of 4 November 1940 in eastern Saskatchewan (Swallow 1941; Erskine 1972; Finley 2001), and I wait their arrival eagerly, as I simultaneously watch satellite images of anti-cyclonic systems breaking over the mountains. Here, I document the timing of their autumn arrival during the last decade, and attempt to relate this to the latest research in freeze-up phenology and climate change.

Methods

My bay-window observatory, situated in Sidney, British Columbia, overlooks Roberts Bay, part of Shoal Harbour Migratory Bird Sanctuary, southeastern Vancouver Island, one of the oldest marine migratory bird sanctuaries on the Pacific coast, established in 1931 (Dawe 1982). Between 1996 and 2005, I kept watch daily for first arrivals in September and October. At least once every morning and at the end of the day during October, I scanned the bay with the aid of binoculars or telescope. In practice, the bay was under observation semi-continuously from either my kitchen window or my study window; however, due to the routines of family life, first scans usually took place between 8:30 to 9:00 h and last scans between 16:00 and dusk. Observations on behaviour, numbers and sex composition were entered in a daily diary, and later transferred to a computer spreadsheet. In most years between 2000 and 2006, total numbers were recorded daily until mid-November. Periods when numbers increased abruptly by more than 30% on two consecutive days were considered as peak influxes.

Results

First arrivals appeared around the 288th day (± S.D. 2.3; n = 10; i.e., 15 October) of the Julian calendar (Table 1). They included singles on three occasions and flock sizes up to eight. Singles included "females" in two cases; drakes were always amongst the first arrivals, accounting for 14 of 38 (37%) of them. Most

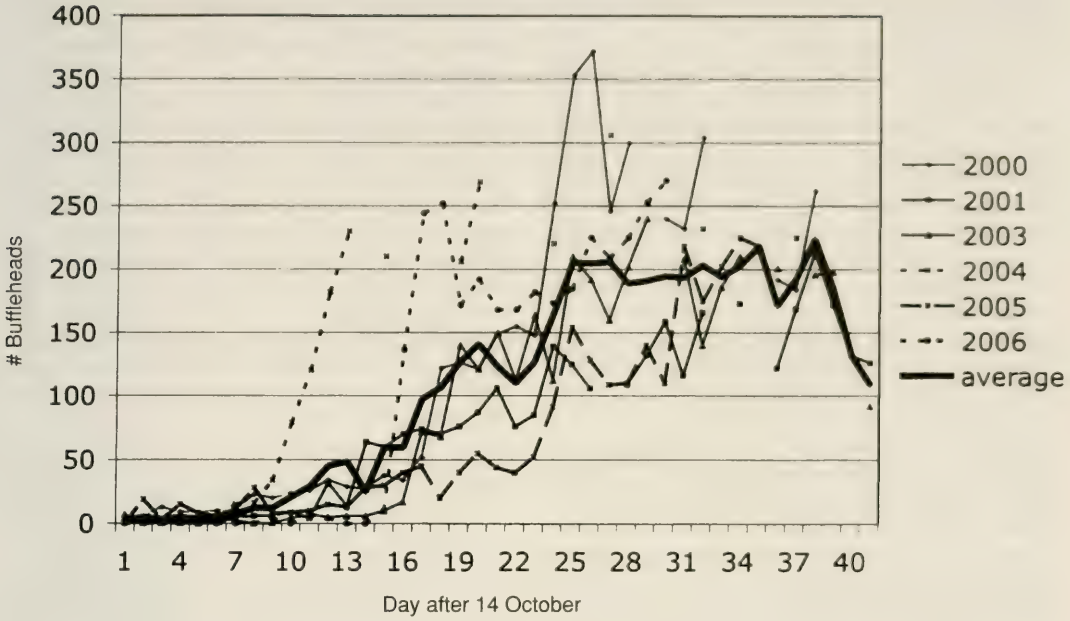

FIGURE 1. Buffehead phenology: autumn numbers of Buffleheads on Roberts Bay, Shoal Harbour Migratory Bird Sanctuary, mid-October to late November, in various years between 2000 and 2006.

arrivals appeared by 09:00, and they always appeared in the same general location (radius about 150 m), around the delta of an estuarine creek. Numbers until late October remained small, averaging less than 6% of peak numbers. First arrivals preceded the first peak influx by about 15 to 20 days (typically the end of October), and a second influx by about 24–26 days (7–9 November), though the first peak was sometimes not evident, e.g., 2001 and 2005 (Figure 1). The percentage of males on various days varied considerably, averaging 42 percent ($n = 38$), with no apparent trend during the influx period.

Discussion

Due to their high albedo and activity, male Buffleheads are difficult to overlook, and because Roberts Bay is just the right size, I'm confident that the data presented here are reliable. Their timing, first thing in the morning, indicates their propensity for nocturnal navigation. Though the precise timing is biased by my morning schedule, it is evident that they arrive sometime after dawn, conveniently around breakfast time, as enviously noted by Erskine (1972). On several occasions, it was apparent that they had just touched down, and on one occasion, 15 October 2003 ("All-Buffleheads Day"), I saw them fly in and land. First arrivals were often flighty, sometimes disappearing and returning during the day, or disappearing for several days, but most took up residence and courtship right away.

Throughout October and into November, new arrivals remain mostly in the core area where they initially landed, and intense courtship takes place before birds take up their feeding territories. This initial touch-down zone is a central arena in Bufflehead society, to which known individuals of monogamous pairs return year after year (Finley, unpublished). Such philopatry, or "home-loving" behaviour, is a genetic trait passed on over generations, providing a survival advantage through intimate knowledge of their environs, culturally transmitted through the wisdom of successful mature individuals. Thus, philopatric Buffleheads are "homing in" on their tribal territories, and they do so, in a punctual manner.

Buffleheads show a high degree of synchronicity and phenological precision in their life cycle, hatching out in latitude 52°N on Julian day 169.5 ± SE 1.6 (18 June; Evans et al. 2002) and, about 119 days later, arriving on their wintering grounds, in latitude 48°N. These life events, synchronized with the solar cycle, represent significant seasonal demarcations in the calendar of temperate boreal, aspen-parkland ecosystems. Not only do Buffleheads show punctuality by their solar calendar, but they also synchronize their

daily life precisely with light levels (Finley 2007). They are an exemplary model of precision and punctuality, daily and seasonally.

Erskine (1972: 128) noted that "Reported first arrivals are often single birds moving a month or even more before migration gets under way in earnest." Erskine also reported that only isolated individuals appeared before 10 October. He illustrated the isolines of migration fronts in 1962 over North America, although the entire coast of British Columbia fell into a zone of uncertainty between 11 and 21 October. Using published records and questionnaires, Erskine calculated arrival dates over the twentieth century for various locations on Vancouver Island and Puget Sound, Washington, noting that "few observers are in a position to observe bufflehead habitat daily or even weekly, and many first dates represent only the time of first visit to a particular area". Still, he found the averages were remarkably uniform around 18 October (S.D. ± 2 around five regional means, based on 45 records) for five locations on Vancouver Island between 1903 and 1962. Victoria averaged 18 October based on eight years between 1955-1962. If anything, the potential bias by discontinuous observation would be toward a later date as suggested by this study. Or, as Erskine has suggested (personal communication, 2008), first arrivals might appear slightly earlier in prime habitat like Roberts Bay, rather than in adjacent areas.

Erskine (1972) estimated that the first general movement from the breeding grounds began around 20 October, and observed that peak migration across the continent was highly concentrated during the first week of November, noting the concurrence of this movement with the "Great Bufflehead Crash" on 4 November 1940 (Swallow 1941; Finley 2001). Bellrose (1976) remarked that this first wave of migration occurred at "surprisingly similar times" across the northern plains. Erskine (1972) believed that migration peaks were correlated with mean temperatures and the timing of freeze-up, and – lacking the instantaneous advantage we have today of viewing the earth on-line – he illustrated the general weather system that forced mass movements of Buffleheads out of their breeding grounds. An example of this system, the first sustained high pressure system in the Mackenzie Basin, is illustrated by Woo et al. (2007). Because the thermodynamics of freeze-up are a good integrative measure of climate (Menard et al. 2002; Jefferies 2005), the phenology of Bufflehead autumn migrations should be a good proxy indicator of the advance of the zero degree isotherm, and thus of climatic variability.

Buffleheads presumably respond to seasonal changes in light levels, mediated by the pineal gland, such that light levels induce "zugunruhe", or migratory restlessness (Welty 1975). They arrive here two or three days after the average date of freeze-up of their most northerly breeding grounds in central Alaska (Jefferies et al. 2005). Thus, the onset of migration may represent a threshold effect of the mid-October photoperiod, whereas the first major influx in late October may represent a thermodynamic threshold associated with general freeze-up, a reliable indicator of the first significant outflow of arctic air, and the advance of the zero degree isotherm. The exact timing of the first influx is determined by weather patterns and the need for clear nights for celestial navigation, conditions typical of high-pressure air masses, in the aftermath of a front. The earliest influx, beginning 23 October 2004, corresponded to the first snowfall on the prairies. The rapid increase to peak numbers on 30 October 2006 was due to a major incursion of arctic air and a rapid freeze-up throughout the west, whereas the delayed build-up in 2005 was due to warmer than normal conditions, and late freeze-up (Environment Canada 2006*). The first influx was not always marked (e.g., 2001 and 2005), but the last one tends to occur just before Remembrance Day (11 November) and may represent the climatic domain and freeze-up phenology of the interior of British Columbia, and/or the arrival of a different component of the population.

I did not monitor numbers continuously in 2007 but did note influxes on 27 October and 11 November, the latter preceding the first major storm front of what was to become La Nina's infamous winter from hell. This latter influx included a distinctive female of a pair that has returned annually to the same territory for the past three years, so it may be that the breeding pairs are amongst the last to arrive, having re-joined in the interior before their overnight flight. Lack of any clear trend in the male composition of flocks suggests that re-integration of the sexes and pair re-bonding occurs prior to migration, even though I once observed a bachelor flock of two hundred on the Nicola Lake marsh, near Merritt, British Columbia, as late as 6 November 2000.

Evidently the timing of first arrivals and peak autumn movements has not advanced during the latter half of the twentieth century, even though the Mackenzie Basin region has experienced the greatest warming in Canada in the last five decades, by as much as 1.5°C (Woo et al. 2007). However, the temperature increase has occurred only in winter; summer temperatures have shown no trend and freeze-up time has remained consistent (Duguay et al. 2005; Jefferies 2005). Thus, although ice duration has decreased over the last two centuries due to global warming, it is not due to later freeze-up but rather to earlier break-up. If a slight change in air temperature is sufficient to shift freeze-up dates by several weeks, one would expect that the peaks of Bufflehead migration would shift accordingly over decades. In fact the timing of the first influx does not appear to have changed in decades, falling within the average range of freeze-up time in Back Bay, Yellowknife (Menard et. al. 2002).

Menard et al. (2002) found that computer simulations of freeze-up dates were later by six days than actual observations. Undoubtedly, the timing and volume of Bufflehead flights are a more precise and inte-

TABLE 1. First arrivals of Buffleheads on Roberts Bay, 1996–2005.

Year	October	Julian day	Time	Total Number	Number of males
1996	17	291	09:00	6	2
1997	13	286	-	8	2
1998	16	289	14:00	2	2
1999	15	288	12:00	4	1
2000	12	286	11:15	1	0
2001	15	288	08:30	1	1
2002	13	286	09:00	3	1
2003	15	288	08:35	7	3
2004	19	293	08:30	5	2
2005	15	288	08:40	1	0
Average ± S. D.		288.3 ± 2.3		3.1 ± 1.5	1.4 ± 0.9

grative measure of freeze-up. The narrow variation found in this study suggests that monitoring of their numbers from certain localities, in conjunction with shore-based observations of freeze-up, would (a) help validate one-dimensional thermodynamic models, (b) add a light-sensitive ecological indicator, representing the advance of the 0°C isotherm, and (c) provide a more meaningful index of climate change across the western boreal region, at minimal cost. This could be achieved through citizen participation.

Long dismissed as amateur natural history, phenology has become popular again with the rise of citizen participation in environmental and ecological monitoring programs. More and more citizens, concerned about the impacts of global warming, are participating in "earth-watch" programs, creating phenological statistics by which to gauge environmental change. Haupt (2006) argued that lay people need to reclaim natural history and become involved in their own biological education. What better way, she suggested, than to keep a diary "phenological awareness immerses us in the rhythmic dimensions of the natural world ... we become engaged, watchful, and increasingly resident."

But a phenological notebook has little meaning unless observations are carried on diligently beyond the typical limited time frame of biological studies; only then can meaningful statistics be generated. Most phenological studies naturally emphasize the early arrival of spring migrants as indicative of a climate change in the northern hemisphere (Cotton 2003); however, the accumulated energy budget of boreal aquatic ecosystems is determined by the switch-off date, tripped by "old Jack Frost," setting the Bufflehead in motion. In a climate of change, the punctual Bufflehead is a comforting constant. *Bucephala exclararet nos.*

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Dedicated to Valerie. I'm honoured to have received the expert advice of the author of *Buffleheads*, Tony Erskine, and of the father of prairie ornithology, C. Stuart Houston.

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Offshore Flight of Buffleheads, *Bucephala albeola*, After Twilight in Winter: An Anti-Predation Tactic?

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Finley, James K. 2007. Offshore flight of Buffleheads, *Bucephala albeola*, after twilight in winter: an anti-predation tactic? Canadian Field-Naturalist 121(4): 375-378.

In winter, on Vancouver Island, Buffleheads depart from coastal marine feeding habitat shortly after the onset of civil twilight. This precisely-timed phenomenon may have evolved in response to predation pressure from Peregrine Falcons, *Falco peregrinus*. The dual habitat requirements of Buffleheads in Shoal Harbour Migratory Bird Sanctuary (1931) and Sidney Channel Important Bird Area are to be included within the proposed Gulf Islands National Marine Conservation Area.

Key Words: Bufflehead, *Bucephala albeola*, timing, crepuscular flight, anti-predation, dual habitats, British Columbia.

Time, timing and habitat structure are key elements in the evolution of anti-predation behaviour. Many species' behaviours are synchronized with shifting light levels to reduce the risk of attack. Genetic clocks are set by aeons of predatory pressure.

At least since the Pleistocene, Buffleheads (*Bucephala albeola*) have returned from their interior breeding grounds to limited marine wintering habitat on the east and west coasts of North America (Erskine 1972; Gauthier 1993). A large portion of the western population winters in coastal waters of the Strait of Georgia and Puget Sound (Salish Sea) where they occupy sheltered coves like Shoal Harbour Migratory Bird Sanctuary, on the southeastern coast of Vancouver Island (Dawe 1982*). Established in 1931, the sanctuary includes inter-tidal mudflats that support high densities of benthic invertebrates, prime feeding habitat (when covered with water) for Buffleheads. Buffleheads feed intensively during the day but what they do at night is largely unknown. Here, I document a precisely timed phenomenon, the Bufflehead's offshore flight after twilight.

Methods

This study was conducted from my home observatory in Sidney, British Columbia, overlooking Shoal Harbour Migratory Bird Sanctuary on southeastern Vancouver Island, adjacent to Sidney Channel "Important Bird Area" and the new Gulf Islands National Park Reserve (Figure 1). My bay-window overlooks Roberts Bay, a rich inter-tidal mud flat, prime Bufflehead habitat from mid-October to early May. Monthly surveys of the sanctuary have been conducted since 2000 as part of the Coastal Waterbird Surveys, a citizen-based monitoring initiative of Bird Studies Canada and the Canadian Wildlife Service, Environment Canada (Badzinski et al. 2006).

Casual observations occurred every day between October and May, from my vantage 4-6 m above sea level, with a westerly view such that Buffleheads can be seen in silhouette at dusk, and against background residential lighting. Observations of their departure time (Pacific Standard Time) were recorded opportunistically between January and May in 2000 ($n = 29$), 2004 ($n = 15$), 2005 ($n = 12$) and 2007 ($n = 5$). Typically the flock departed in waves close together and departure time was recorded to the nearest minute. Sometimes, especially toward spring, departure was spread out over several minutes, though the majority of birds typically departed en masse. In such cases, the median departure time, when the majority left, was used in the analyses. Data were entered on a computer spreadsheet along with a table on sunset and twilight times for latitude 48°N (Victoria). Regression analysis was performed with Microsoft Excel software.

Civil twilight is defined when the sun is 3 degrees below the horizon and there is sufficient illumination, in clear conditions, for the average human eye to distinguish terrestrial objects, and the horizon remains distinct (U.S. Naval Observatory website). Nautical twilight occurs when the sun is 6 degrees below the horizon, the general outlines of objects may be distinguishable, and the horizon is indistinct.

Results

The late winter (January to March) population of Buffleheads on Roberts Bay was relatively stable at 130 ± S.D. 33, $n = 16$. Typically, around sunset, these birds began to gather near the southwestern shore, especially around the delta of Mermaid Creek, where they engaged in social activity and preening before coming to a rest, heads tucked, tails erect. During the brief rest period, the flock was often arrayed in lines near shore, facing offshore, with a few alert individuals. Imminent departure was often evident by abrupt alertness of the flock, followed by swimming toward the mouth of the bay. Small groups or pairs sometimes departed in advance of the main movement, but typically, the flock departed close together, about 10–12 minutes after the onset of civil twilight, before the onset of nautical twilight. The slope of the departure regression

line parallels the seasonal advance of civil twilight (Figure 2). One exception fell significantly before the twilight threshold; this occurred on 3 February 2007 when the flock departed 27 minutes earlier than expected.

Discussion

The offshore departure of Buffleheads after civil twilight is a precisely timed phenomenon, presumably set by their genetic clock, and hormonally mediated by the pineal gland (Welty 1975). Undoubtedly some of the variation was due to the effects of cloud cover; a more precise correlation could likely have been obtained if a light meter had been used. Surprisingly, there is no mention of this daily scheduling activity in the literature (Munro 1942; Erskine 1972; Gauthier 1993), nor of similar behaviour in the waterfowl literature, although it is generally recognized that waterfowl tend to fly around sunset. Perhaps their daily flight has been overlooked because most biologists are sitting down to supper and the news, or — maybe more so — because we live by the clock and tend to take such scheduling for granted.

Buffleheads appear to be obligatory nocturnal migrants, famous for their crash on 4 November 1940, caused by unusual weather and artificial lighting conditions in Saskatchewan (Swallow 1941; Erskine 1972; Finley 2001; Eyolfson 2006). Nocturnal migration, timed to coincide with favourable tailwinds and clear skies, may have evolved due to the energetic demands of the Bufflehead's small size and their need to feed during daylight. This physiological factor in long-range migration appears irrelevant to their daily schedule, although in both cases their flight is initiated after sunset. Perhaps their daily offshore flight is an anti-predation tactic.

Three predators, River Otters, *Enhydra lutra*, Peregrine Falcons, *Falco peregrinus*, and Bald Eagles, *Haliaeetus leucocephalus*, prey on Buffleheads on their west coast wintering grounds. Buffleheads are highly vigilant for otters, and distinguish them from Harbour Seals (*Phoca vitulina*). Most successful predation attempts that I've observed have involved otters, often a couple of times each season, usually in rough seas, and at any time of day though perhaps more frequently in low light conditions. If Buffleheads are more vulnerable to otters in low light, one would expect that they would depart from coastal waters well before twilight.

All other successful attempts have involved the resident pair of eagles, which overfly the sanctuary throughout the day. Bald Eagles take the occasional Bufflehead by either surprising them, or hovering and forcing them to tire; however, this is a demanding strategy, not often seen. Though mildly alert to their flights, Bufflehead do not normally take evasive action unlike the resident Wigeon (*Anas americana*). Yet eagles can be effective predators; just this past December, the pair, working in tandem, took two in succession within an hour. It seems that they take primarily juveniles and weak birds,

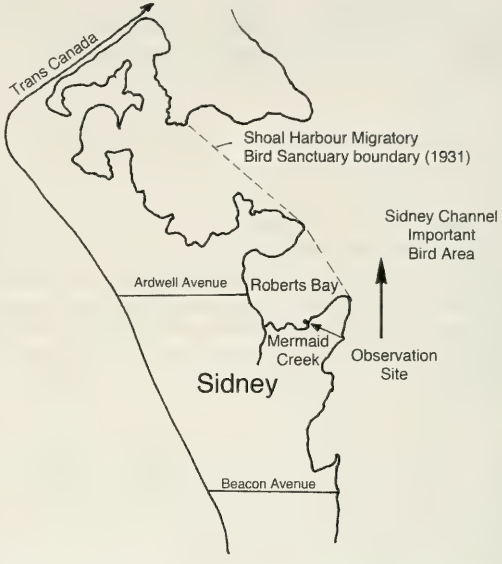

FIGURE 1. Shoal Harbour Migratory Bird Sanctuary in Sidney by the Salish Sea, prime Bufflehead habitat in winter.

perhaps more often during the coldest days of midwinter, and at any time of day. Only once have I observed an eagle take a drake, but it happened under unusual circumstances involving a Peregrine Falcon.

In contrast to their relaxed vigilance toward potential eagle predation, Buffleheads show a heightened alertness to peregrines. On the occasion just mentioned, a peregrine stooped on a flock, causing a panic of diving, and with "split-second" timing, an eagle, that had evidently anticipated the reaction, launched itself from its fir snag and snatched a surfacing drake. Although I recall only a handful of hazings and unsuccessful predation attempts over the years, I suspect that peregrines might be the driving force behind the Bufflehead's precise departure time. This speculation is based on two anecdotes.

The first occurred on 24 November 2000, when a peregrine passed over the bay just before dusk, causing the Buffleheads to remain highly alert, close in, obscured in the shadows of the south shore. When forced to take flight by a pedestrian just before the end of civil twilight, they did so hesitantly and in a notably chaotic "crash-diving" maneuver. At this time the peregrine stooped, missed, and continued pursuing individuals into the darkness. A few Buffleheads returned near shore and remained until it was too dark for me to detect them. I'd seen the Bufflehead's crash-diving evasive tactics before, though not in the presence of a predator. Evidently it was a practised procedure, like the orchestrated flight drills of the Dunlin (*Calidris alpina*) on the Fraser River delta (Dekker and Ydenberg 2004). The second anecdote happened to be my last data entry (3 February 2007) in

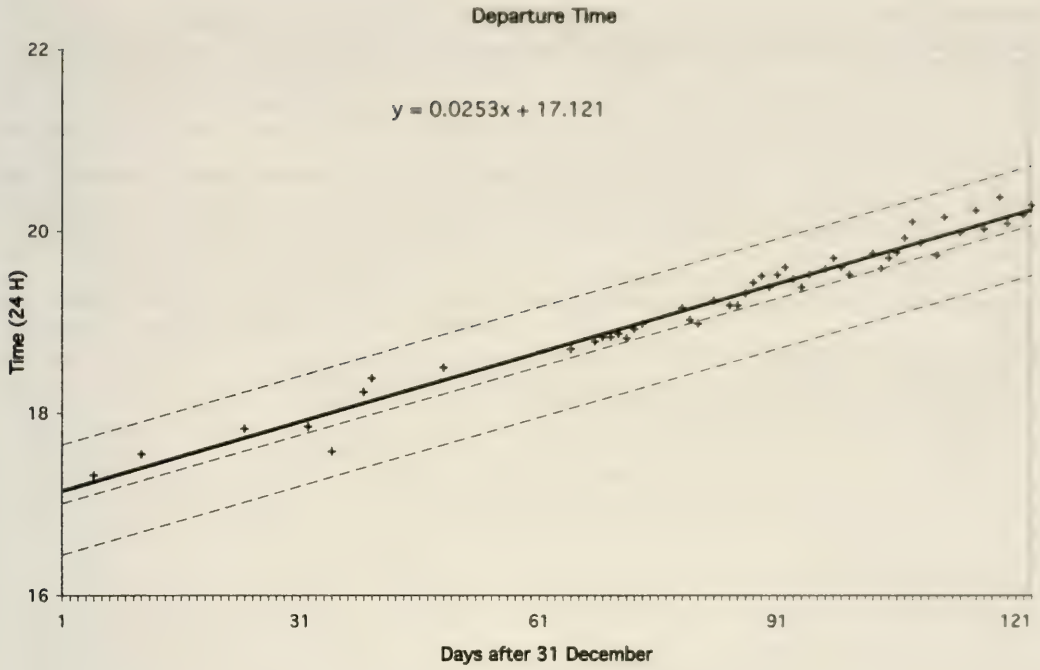

FIGURE 2. Evening departure times of Buffleheads from Shoal Harbour Migratory Bird Sanctuary, January to May 2000-2007. The single exception before civil twilight involved anti-predator maneuvers. The upper dashed line is nautical twilight, the middle is civil twilights, and the lower is sunset.

Figure 2, the only data point to fall before civil twilight and it was one of the rare occasions when they showed evasive flight tactics. Perhaps it was a practice procedure or maybe they sensed a peregrine.

So why do they depart so precisely after twilight? Once aptly called the Duck Hawk, the peregrine is known to be able to hunt in low light levels, and to take crepuscular species such as the Sora (*Porzana carolina*; Nero 2000) and bats. The timing may represent the peregrine's threshold for effective light levels in which to hunt. Peregrines were once more abundant and presumably a much greater threat over eons. Paine et al. (1990) have shown that their recovery has had a marked influence on the structure and integrity of a seabird colony in nearby Washington State. And why, I wonder, do the Buffleheads always depart from one side of the bay? At first I assumed this choice was because the south side was in the lee and around the delta of Mermaid Creek, but now wonder whether it might have more to do with it being on the shaded side of the bay, and their flight trajectory into the darkest horizon within the limits of nautical twilight, less than two feet off the black water, like a Petit Garrot or "Shotbolt".

Although it is thought that Bufflehead populations are not limited by predation (Erskine 1972), this study suggests that predation may strongly shape their behaviour and habitat choice. Just because predation is seldom observed, does not mean that it is not operating in powerful and subtle ways. Although predation pressure and light thresholds might determine the schedule of departures, their daily commute between nocturnal offshore roosting habitat and essential feeding habitat may have evolved due to a complex of other factors.

Where do the Buffleheads go at night? Not far, I believe. On two occasions I've seen some of them land at dusk in adjacent channels of the Gulf Islands, including Sidney Channel "Important Bird Area", a UNESCO-designated site of international importance. This area, including Shoal Harbour Migratory Bird Sanctuary, is presently being evaluated as part of a proposed National Marine Conservation Area. Thus the dual habitat requirements of Buffleheads may be included within a world view.

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Diets of Overwintering Caribou, *Rangifer tarandus*, Track Decadal Changes in Arctic Tundra Vegetation

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We compared winter diets of Western Arctic Herd Caribou (*Rangifer tarandus*) from 1995/1996 and 2005 using microhistological fecal analysis on samples collected at paired permanent vegetation transects. Changes in the diets of Caribou followed the same trends as vegetative changes documented in long-term studies in northwestern Alaska. Lichens were significantly less prevalent on the landscape and in the winter diets of Caribou between 1995/1996 and 2005, while graminoids (grasses and sedges) were significantly more prevalent. Dramatic changes are forecasted for Arctic ecosystems under global warming scenarios which may continue the trend of declining lichens in northwestern Alaska and in the diet of Western Arctic Herd Caribou. The question of whether or not the altered diet will affect the population dynamics of this herd remains unresolved.

Key Words: Caribou, *Rangifer tarandus*, diet, fecal analysis, climate change, habitat, Western Arctic Herd.

The Western Arctic Herd (WAH), with nearly 500 000 Caribou (*Rangifer tarandus*) as of 2003, is currently one of the largest in the world. Population level records of the herd date back to 1970 when the herd was estimated to be 242 000 Caribou (Dau 2005a). The WAH crashed between 1970 and 1976, falling to 75 000 Caribou (Dau 2005a). It rebounded quickly from this population low, growing at an annual rate of about 13% for more than a decade and reached 416 000 Caribou in 1990 (Dau 2005a). Growth has continued, albeit at a more measured 1% average annual growth rate, reaching 490 000 in 2003 (Dau 2005a). The WAH is an important subsistence resource for approximately 30 villages in northwestern Alaska (Dau 2005a) which harvest nearly 500 000 kg of meat from this herd annually (Valkenburg 1994). Changes to the range on which this herd depends is therefore a subject of interest to the inhabitants of the region, sport hunters, wildlife enthusiasts and land managers. Our goal was to monitor changes in the vegetative characteristics of the herd's winter range, quantify the diets of Caribou utilizing this range, and track changes that have occurred since the previous decade.

The effects of global climate change are currently being expressed in the Arctic. Already documented are warming temperatures, melting glaciers, reduction of pack ice extent, shrinking lakes, and alteration of vegetative communities (Hansen et al. 1999; Serreze et al. 2000; Sturm et al. 2001; Smith et al. 2005). In terms of arctic vegetation specifically, lichen abundance is predicted to decline while vascular shrubs and graminoids (grasses and sedges) may increase (Chapin et al. 1995; Cornelissen et al. 2001; Walker et al. 2006). Though Caribou grazing and trampling have been implicated as major factors in reduced lichen abundance (Moser et al. 1979; Messier et al. 1988; Arseneault et al. 1997; Joly et al. 2007b), climate change may further exacerbate declines. Lichens are thought to be a critical component of the winter diet of large, migratory herds in northern North America (White et al. 1981; Klein 1991). Poor winter range conditions can affect body condition, fetal growth, calf birth weights, milk production, and calf growth rates (White 1983; Parker et al. 2005). Declines in these vital signs could result in reduced herd productivity; therefore, changes in vegetation has the potential to affect Caribou populations and people who depend on them.

Methods

Joly et al. (2007b) investigated 25 permanent vegetation transects, originally deployed in 1981, in 1995 and 1996 (1995/1996) and then reexamined them in 2005. All transects were located in and around the Buckland River valley, which is entirely within the core winter range of the WAH in northwestern Alaska, USA (Dau 2005a; Joly et al. 2007a). Joly et al. (2007b) laid out a sampling frame (1.0 × 0.5 m) every 4 m along the 50-m transect for a total of 12 frames per transect. The frame was strung every 10 cm along both axes, which created 50 intercepts. The first species observed under the intercept was recorded and a percent cover was derived. Each species was assigned to one of following categories: lichen, graminoid, moss, shrub, or forb (see Joly et al. 2007b for more details). Un-vegetated observations (e.g., rocks) were assigned to a different category.

We collected composite fecal samples at 24 of these same transects both in 1995/1996 and in 2005. At one

TABLE 1. Changing percent cover of various vegetative categories comprising the core winter range of the Western Arctic Herd, northwestern Alaska, USA from 1995/1996 and 2005 (adapted from Joly et al. 2007b). Note that percentages do not tally to 100% because the un-vegetated class is not reported here.

Class	1995/1996	2005	Change	P	T	df
Lichens	16.8	12.5	–	0.004	3.21	24
Graminoids	25.3	31.9	+	0.001	4.39	24
Moss	5.9	6.1	/	0.673	0.43	24
Shrubs	30.1	32.8	+	0.045	2.12	24
Forbs	5.9	3.9	–	0.001	3.86	24

TABLE 2. Changing percentage of various vegetative categories in the (uncorrected) diets of Caribou in the Western Arctic Herd, northwestern Alaska, USA from 1995/1996 and 2005.

Class	1995/1996	2005	Change	P	T	df
Lichens	58.5	50.6	–	0.001	3.73	23
Graminoids	15.0	21.6	+	0.002	3.53	23
Moss	16.1	14.5	/	0.351	0.95	23
Shrubs	7.2	8.6	/	0.169	1.42	23
Forbs	3.2	4.5	/	0.155	1.47	23

of the 25 transects we were unable to locate enough samples to conduct analyses. Each composite sample contained about 20 winter (based on form and herd distribution) fecal pellets collected from different pellet groups – one pellet per group. In a few cases, when 20 individual pellet groups were not available, we took two pellets from each group. The samples were frozen and then shipped to a laboratory (see Acknowledgments) for composition analysis. All samples from both sampling periods were analyzed by the same technician during the same session to reduce potential sources of error (see Russell et al. 1993). The relative density of plant fragments was based on 100 fields per sample.

The uncorrected results were compared to changes in vegetative cover determined from the permanent transects. The uncorrected fecal analysis results provided estimates of diet composition but did not provide proportions of ingested diet (Boertje et al. 1985; Russell et al. 1993). Unfortunately, a large percentage (> 80%) of the shrub particles were classified as "Other" or "Unknown", so we were not able to determine if they should be classified as evergreen or deciduous shrubs. Therefore we were unable to apply Russell et al.'s (1993) correction factor for digestibility. Paired t-tests were employed to identify significant changes in percent cover and diet between 1995/1996 and 2005. We calculated Ivlev's index of selectivity (Ivlev 1961) using the formula: (U-A) / (U+A), where U (utilization) was the amount of a vegetation type found in the fecal matter and A (availability) was the percent cover of that type found on the paired transect.

Results

The permanent vegetation transects indicated changes in vegetation from 1995/1996 to 2005 in the winter range of the WAH. Significant declines in lichen abundance were noted, while both graminoids and shrubs increased during this time period (Table 1; Joly et al. 2007b).

The changes in vegetative cover were mirrored by changes in the paired fecal composition of WAH Caribou between 1995/1996 and 2005 (Table 2). The proportion of lichen found in the fecal pellets declined significantly ($T = 3.73$, $P < 0.001$, $df = 23$), while the proportion of graminoids increased ($T = 3.53$, $P < 0.0021$, $df = 23$). The mean proportion of *Cladina* spp. declined from 21.8% to 15.2% from 1995/1996 to 2005 ($T = 4.71$, $P < 0.001$, $df = 23$). This decline in *Cladina* spp. represented 84% of the decline in overall lichen in fecal matter over this time period. There were no significant differences in the proportion of *Cetraria* spp., *Cladonia* spp., or non-preferred lichens (e.g., *Alectoria* spp., *Bryoria* spp., *Peltigera* spp., etc.) between 1995/1996 and 2005. There were no significant differences in the other vegetative classes (Table 2).

Lichens and mosses were found in the fecal matter of WAH Caribou more than they were present in the environment in both 1995/1996 and 2005 (Figure 1). Ivlev's (1961) index of selectivity increased for lichens between 1995/1996 and 2005, despite declines in lichen availability. The index decreased for mosses as its availability declined (Figure 1). Graminoids and shrubs were more common on the landscape than in the fecal matter of Caribou in both 1995/1996 and

FIGURE 1. Ivlev's index of selectivity for Caribou utilizing different vegetative categories on the winter range of the Western Arctic Herd, northwestern Alaska, USA. Light-colored bars represent data from 1995/1996 and the dark bars from 2005. An index of 0 would occur when the amount of that category was found in equal percentages in the fecal matter and along paired permanent vegetation transects. Ratios > 0 reveal vegetation types that were greater in the diet than found on the landscape. Ratios < 0 reveal vegetation types that were less prevalent in fecal matter than on the landscape.

2005 (Figure 1). Ivlev's (1961) index of selectivity declined between 1995/1996 and 2005 in the face of increasing availability of these vegetation types.

Discussion

Lichen content in the winter diet of Caribou has been reported to be from 62 – 69% (Thompson and McCourt 1981; Boertje 1984; Boertje et al. 1985; Russell et al. 1993). While our results show somewhat lower lichen content (51 – 59%), we were not able to apply correction factors to account for differential rate of digestibility among vegetation types. Lichen content is typically under-represented without correction factors (Russell et al. 1993), so our results are likely similar to these previous studies (though see Boertje et al. 1985).

We know of no other studies that have tracked the diets of Caribou over a decade and directly related detailed vegetative cover surveys to dietary analyses. Our results show that the recent winter diet of WAH Caribou contains less lichen and more graminoids than in the past, tracking changes in vegetative cover from 1995/1996 to 2005 reported by Joly et al. (2007b). The percent of lichen in the fecal matter was 3.5 – 4 times greater than the percent of lichen cover in the environment, suggestive of selection. Caribou used areas of high lichen cover more than other areas (Joly et al. 2007b). The significant reduction of *Cladina* spp. in the fecal matter between time periods was also reflected in declines of primary forage lichen on the landscape (Joly et al. 2007b). Grazing was likely a factor that drove the decline in lichen in northwest Alaska (Joly et al. 2007b). It may take a couple of decades for lichens to recover from intense grazing, barring further disturbance (Henry and Gunn 1990).

Shrubs are significantly increasing in the Arctic (Sturm et al. 2001; Joly et al. 2007b); however, we did not detect a corresponding increase in shrubs in the diet of WAH Caribou. Shrub expansion could have negative impacts on individual Caribou energetics and multiplier effects on the herd (see Lawler and White 2006). Other researchers have reported increased moss cover where Caribou range has been heavily grazed (Klein 1987; van der Wal 2006), but changes in moss cover were not detected within the range of the WAH during this time period (Joly et al. 2007b). Mosses were present in the fecal matter in greater percentages than were found on the landscape; however we believe this is due to its low digestibility rather than Caribou selecting for this forage type (Boertje et al. 1985).

Climate warming is another factor that has been implicated in declining lichen cover within the range of the WAH (Joly et al. 2007b). Fire activity is strongly correlated with warm summer temperatures in Alaska and Canada (Duffy et al. 2005; Kasischke and Turetsky 2006). The frequency and extent of fires is predicted to increase due to global warming (Rupp et al. 2000; McCoy and Burn 2005). Lichens within the range of the WAH are slow to recover from wildfire, often taking many decades to recover to initial levels (Arseneault et al. 1997; Jandt et al. 2008). Overwintering Caribou are known to avoid burned areas in both tundra and boreal forest, in northwest Alaska, for up to 55 years (Joly et al. 2007a). Lack of lichens

in these areas has been hypothesized to be a reason for this avoidance though other factors have been suggested (see review by Klein 1982).

Lichen cover has been declining in the study area since 1981 (Joly et al. 2007b). Potential outcomes of continued declines in lichen cover in winter range include range shifts and population-level effects (Ferguson et al. 2001; Joly et al. 2007b). Caribou nutritional status should not be assessed based on lichen abundance alone (Boertje 1990). Studies in the high Arctic studies have shown that Caribou can be less reliant on lichens (Thomas and Edmonds, 1983; Adamczewski et al. 1988). However, these Caribou do not face the predatory pressure and migratory expense that WAH Caribou do and also differ phenotypically. Additional differences between these types include greater ability of the high Arctic Caribou to store fat and digest graminoids and mosses (Tyler 1987). Large, migratory herds of barren-ground Caribou, like the WAH, are thought to be reliant on abundant terricolous lichens (White et al. 1981; Klein 1991; Heggeberget et al. 2002). Nevertheless, it has been suggested that Caribou may not be negatively affected by a change from a lichen-rich diet to a graminoid-rich diet as ecosystems transition to graminoid-dominated states (van der Wal 2006).

Adult survival rates would be the least sensitive population parameter to potential declines in nutritional status, so biologists and managers should monitor pregnancy rates and calf to cow ratios to detect early signs of nutritional stress. Declines in these parameters may imply that the nutritional status of the herd is declining due to poor range conditions and that the transition to a graminoid diet may impact the herd. Recruitment in the WAH has been slowly declining (Dau 2005a) and the most recent photo-census (2007) revealed a 20% decline in the herd (J. Dau, personal communication), which may be incipient indications of the importance of lichens to this herd. Predation is not likely a major factor in these declines with the herd size being so large and predator densities relatively low (Ballard et al. 1997; Haskell and Ballard 2007), though density-independent icing events may be a factor (Dau 2005b). Although the debate over the relative importance of lichens in the winter diet of Caribou remains unresolved, our results reveal that WAH Caribou use lichens extensively in the winter despite their declining abundance on the landscape in northwestern Alaska.

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An Analysis of the Historical Records for the Native Mammalian Fauna of Prince Edward Island

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A search was carried out for historical records, both published and unpublished, that make reference to the native mammalian fauna of Prince Edward Island. Based on documents dating from 1721 to 1890, a comprehensive list of the records for the native mammals of the island has been compiled. Among the new information found is evidence for the presence of the Grey Wolf (as well as the Woodland Caribou) at the time of the first French settlement in 1720, and for the absence of the Beaver and Moose. Historical information has been assembled on the abundance and food-chain relationships of each of the mammalian species, as well as on their interactions with the European population, including the attitudes of the new settlers towards each species. The records indicate that seven of the mammals were extirpated: the Grey Wolf, American Black Bear, American Marten, River Otter, Canada Lynx, Atlantic Walrus and Woodland Caribou. All of these extirpations were due to the activities of the European population, with the attitudes of the settlers contributing to four of them: an indifference to the survival of the otter and Marten, and a direct hostility to the bear and lynx (due to their predation on livestock), leading to the payment of bounties.

Key Words: historical records of mammals, mammalian fauna, Prince Edward Island, Grey Wolf, American Marten, Atlantic Walrus, Woodland Caribou, Moose, Beaver.

At the time of the first European settlement on Prince Edward Island in 1720, the island supported a varied mammalian fauna. In the course of the next 180 years, the native fauna was to become greatly reduced, with six terrestrial species (five of them predators) and one marine mammal being eliminated from the system. Despite an awareness of this general picture (e.g., Clark 1959), the many historical accounts relating to the island's native mammalian fauna have never been subjected to comprehensive analysis. It was hoped that a detailed examination of the records would not only reveal what species were present when European settlement began, but also yield information on the interactions between the native fauna and the European population, including the extent to which the fauna contributed to the food supply of the human population and to any fur-trade economy that developed, as well as an understanding of the factors that led to the extirpation of most of the fur-bearing predators. Initially, my aim was to examine only the records for the terrestrial fauna, though later the pinnipeds occurring in island waters (i.e., the seals and the walrus) were also included.

The historical context

Prince Edward Island (known as Île Saint-Jean to the French) was "discovered" by Jacques Cartier in 1534. However, historical accounts in any significant numbers only begin to occur from 1720, the year of the arrival of some 250 colonists from France. (See Clark (1959) for an in-depth study of the island's historical geography.) Prior to the arrival of the French, aboriginal use by the Mi'kmaq appears to have been confined to the summer period, as part of their seasonal migration to the coastal areas of the Maritimes, though with the establishment of the first French settlement some of the Mi'kmaq began to spend the whole year. The French population grew slowly, so that by 1748 there were only 735 persons. However, numbers then rose sharply, reaching almost 5000 by 1758, due to the arrival of Acadian refugees from the Bay of Fundy area on account of the political unrest and deportations occurring in Nova Scotia. After the fall of Louisbourg in 1758 almost all of the Acadian population was deported to France by the British military authorities, or fled to the mainland, leaving only a few hundred refugees. From the 1770s British settlement proceeded slowly, with by 1805 the population reaching only 6957. However, it then began to grow exponentially, reaching 71 000 by 1855, when immigration from the British Isles began to end. Even so, natural growth continued, with numbers peaking at 109 000 in 1891 (Clark 1959). This increase in the human population was associated with a decrease in the area forested, and by 1935 only 32% of the land area still had a forest cover (Glen 1997).

Prior to European settlement virtually all of the island's land area of some 5750 km^2 had been covered by old-growth forest, with the predominant forest-type

TABLE 1. Twenty-one lists of the mammals of Prince Edward Island made by different recorders between 1721 and 1890. The lists are in chronological order, with the names of the recorders given below the table; these are fully referenced at the end of the paper. See the main text for the identification of the species. (E = extirpated – i.e., reported as either no longer occurring on the island, or the evidence is for the past occurrence only; A = reported as absent from the island.) [*]

	THE LISTS																					
MAMMAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	TOTAL
'Shrew'																	•				•	2
'Bat'											•		•				•				•	4
'Mole'												A					•				•	2
'Wolf'	•																A			•	•	3
'Fox'	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	21
'Bear'		•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
'Marten'	•	•	•	•	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•	19
'Weasel' or 'ermine'											•		•			•	•	•			•	6
'Mink'			•		•		•		•	•	•	•	•	•		•	•		•	•	•	14
'Otter'	•	•		•	•	•	•		•	•	•		•	•		•	•	•	•	•	•	17
'Wild cat' or lynx		•	•		•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	E	18
'Seals'		•	•		•	•	•		•	•	•	•	•	•			•		•	•	•	15
'Sea cow' or walrus					•		•		•	•	•		E	E			E		E	E	E	11
'Caribou'	•	•			•										E	E	A	E				6
'Moose'	A														E	E	A	A	E	E	E	5
'Deer'								A										A		E		1
'Squirrels'						•	•		•	•									•	•		6
Red squirrel											•	•	•			•	•				•	6
Flying squirrel	•										•	•	•			•	•				•	7
Chipmunk											•	•	•			•	•				•	6
'Beaver'	A																A	A			E	1
'Muskrat'		•		•	•			•	•	•	•	•	•			•	•	•	•	•	•	15
'The plague mouse'		•	•	•		•		•			•		•				•		•	•		10
Other mice and voles		•					•			•		•					•				•	6
'Hare' or 'rabbit'		•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	19
TOTAL	6	11	8	6	11	9	11	6	11	12	16	12	16	7	6	14	19	9	13	15	21	

The recorders: **1** – La Ronde 1721; **2** – Roma 1750; **3** – Franquet 1751; **4** – Pichon 1760; **5** – Holland 1765; **6** – Patterson 1770; **7** – Patterson 1774; **8** – Shuttleworth 1793; **9** – [Cambridge] *c.*1796; **10** – Walsh 1803; **11** – Stewart 1806; **12** – Johnstone 1822; **13** – MacGregor 1828; **14** – Hill 1839; **15** – Lawson 1851; **16** – Bagster 1861; **17** – Sutherland 1861; **18** – Rowan 1876; **19** – Anonymous 1876; **20** – [Lawson] 1877-1878; **21** – Bain 1890.

* List 19 is a composite list assembled from the responses of eighteen men to several questions on the mammals occurring on the island in their "young days", contained in a questionnaire sent out in 1876 to the "oldest inhabitants" by a Charlottetown historical committee; list 20 has been put together from anecdotes on the island's native fauna contained in a series of nineteen articles on pioneer life published in 1877 and 1878 in the *Presbyterian and Evangelical Protestant Union*.

particularly in the central part, consisting of hardwood forest in which American Beech (*Fagus grandifolia*) especially, but also Sugar Maple (*Acer saccharinum*) and Yellow Birch (*Betula alleghaniensis*) predominated (Sobey and Glen 2002, 2004; Sobey 2006). In the eastern and western parts, where there was a higher proportion of poorly drained soils, other forest-types occurred, especially a type of "swamp" woodland, containing Red Maple (*Acer rubrum*), Eastern White-cedar (*Thuja occidentalis*), Black Ash (*Fraxinus nigra*) and American Elm (*Ulmus americana*), as well as a boreal forest-type in which Black Spruce (*Picea mariana*) predominated along with a minority element of Tamarack (*Larix laricina*). The upland hardwood forest in particular was subjected to large-scale clearance for agriculture, with any remnants (often in the form of farm woodlots), undergoing considerable change due to the continual harvesting of selected species for timber and firewood. As well, in all forest-types there were the damaging effects of the ubiquitous forest-fires associated with forest clearance. The removal of this old-growth forest and the alteration of that which remained would have had considerable consequences for the island's mammalian fauna.

Results

From the beginning of European settlement in 1720 there is a regular flow of relevant documents from the French (1720-1758), British (1758-1873) and post-Confederation periods (1873 to *c.*1900). These comprise both published books, such as immigrants' handbooks and travel accounts (most of which were

† See List-makers cited in Table 1 after Literature Cited.

available in the P.E.I. Collection of the Robertson Library of the University of Prince Edward Island), and unpublished documents, including government records and private journals, many of which were housed in the Provincial Archives and Public Records Office in Charlottetown (PEI PARO). Some 58 documents were found that make reference to one or more of the native mammals of the island – these are fully reported in Sobey (2002, 2006). Especially informative are those records where the writer constructed a *list* of the mammals of the island: twenty-one such lists have been assembled in Table 1. Four come from the French period (all based on observations made between 1720 and 1752) and seventeen from the British and post-Confederation periods. Many of these list-makers also made short comments on the abundance and/or ecology of some or all of the mammals, as well as on their relations with the human population.

The lists range from four recorders who mention only six species, to one listing twenty-one. All but four of the list-makers appear to have been resident on the island for at least a year, and most for many years. The exceptions are Franquet (1751†), Pichon (1760†), Walsh (1803†) and Rowan (1876†), who spent from seventeen days to a few months. However, given the elusive nature of most of the mammals, it is unlikely that even the resident recorders would have seen every animal they listed, and it is especially likely that animals that were known to have occurred in the past would have continued to have been listed for some time after their extirpation. Also, there is a likelihood that some of what they record may derive not from their own observations, or even from the anecdotal experience of other island residents, but from general written sources from elsewhere.

Table 1 indicates that, collectively, there is a bias in the selection of the animals recorded. The smaller mammals (the shrews, bats and rodents) were either ignored, or else were treated generically, except by a few of the late nineteenth century "scientific" recorders, such as Sutherland (1861†) and Bain (1890†), whereas a greater coverage was given to those mammals considered "useful" to the human population; i.e., as a source of food or products such as furs. Also, some of the animals received greater attention because of their predation on the settlers' livestock and poultry. The records for each mammal are presented separately below, with the nomenclature and order following that of Scott and Hebda (2004).

Shrews

The Atlantic Canada Conservation Data Centre (ACCDC 2008*) lists five species of shrew as currently occurring on Prince Edward Island: the Masked Shrew (*Sorex cinereus*), Water Shrew (*Sorex palustris*), Smoky Shrew (*Sorex fumeus*), Pigmy Shrew (*Sorex hoyi*), and Northern Short-tailed Shrew (*Blarina brevicauda*). However, the only historical records for the presence of shrews are those of Sutherland (1861†) and Bain (1890†), who recorded the presence of what they called the "shrew mouse" and "shrew mole", respectively (Table 1), both mentioning that it fed on insects.

Bats

ACCDC (2008*) lists four species of bat for Prince Edward Island: the Little Brown Bat (*Myotis lucifugus*), Northern Long-eared Bat (*Myotis septentrionalis*), Hoary Bat (*Lasiurus cinereus*), and Eastern Red Bat (*Lasiurus borealis*). For the Eastern Red Bat there is a sight record only. Not surprisingly, the four recorders who noted the presence of bats (Table 1) listed them as if only one species were present. All four recorders indicated that bats were common during the summer, and Bain (1890†) said that they "[hid] away in some secure cranny in buildings or in a hollow tree".

Grey Wolf

The only certain record for the Grey Wolf (*Canis lupus*) is that of La Ronde (1721†), who said that there were wolves "of a prodigious size" on the island. That he also added that he was sending a wolf pelt back to France from the island, both supports his record and indicates they were vulnerable to the presence of the newly arrived Europeans, though it is not impossible that it was the Mi'kmaq who were responsible for the kill. Since there is no further mention of the presence of wolves in eighteenth century records, it is possible that the Grey Wolf was extirpated shortly after settlement began, or else moved across the ice to the mainland. It is thus surprising that there are a couple of late post-Confederation mentions of its presence ([Lawson] 1877-1878†; Bain 1890†), both of which report, on the basis of anecdotal and second-hand information of unknown date, wolves as transient visitors. What Bain (1890†) says is that "wolves have been known to cross the Northumberland Strait on the ice and visit the Island". If this ever occurred, it was likely to have been long before the 1890s when the island was at the peak of European settlement and forest clearance, and when according to Lohr and Ballard (1996) the Grey Wolf was very scarce on the mainland.

Red Fox

The Red Fox (*Vulpes vulpes*) occurs in all twenty-one lists (Table 1), with several recorders noting it as common (MacGregor 1828†; Sutherland 1861†; Anonymous 1876†; Bain 1890†). Others noted the presence of different colour phases (e.g., Franquet 1751†; [Cambridge] *c.*1796†; Stewart 1806†): red, black, and silver-grey are the most frequently listed, though all noted that the red phase was by far the predominant. A fox fur of any colour seems to have had some value, though it was the blacks and silver-greys that were especially sought after. Stewart (1806†) said that the number of foxes caught on the island was

"very considerable", while the means of catching them included steel traps and shooting (Stewart 1806†; MacGregor 1828†; Hill 1839†). There are varying opinions on the fox's pest status, several persons recording that it occasionally took poultry, though they differ as to whether it attacked sheep (Stewart 1806†; MacGregor 1828†; Johnstone 1822†). As for their natural food, according to Bain (1890†), it was "young birds and quadrupeds", while MacGregor (1828†) more vaguely mentions that they fed "in the woods or along the shore".

Black Bear

The American Black Bear (*Ursus americanus*) was recorded by nineteen of the twenty-one list-makers (Table 1) and during the British period several recorders devoted a paragraph or more to it, and especially to its interactions with the human population. It would seem that in the early years bears were abundant on the island: for example, in February 1780 the ensign of a visiting regiment ([Ritter] 1780††) recorded that his soldiers were shooting the bears that came near their huts at Charlottetown, while the proprietor Shuttleworth (1793†) reported that where he lived (near St. Peters Bay) bears "swarmed to a degree that [he] could not have believed", and the visiting bishop Plessis (1812††) said "they are seen in greater numbers than one would expect". However, just ten years later Johnstone (1822†) noted that they were "decreasing in numbers greatly", with the "few of them yet in the woods" being only "seen occasionally by the inhabitants". There are similar comments on its decline by MacGregor (1828†), Bagster (1861†) and Anonymous (1876†), with by the end of the century, Bain (1890†) saying that bears were restricted to "the large wooded tracts" in the east and west of the island. Since, beginning as early as Stewart in 1806, several writers were predicting the Black Bear's impending extirpation, it comes as a surprise that the last recorded bear on Prince Edward Island was shot in 1927 (Hornby 1987).

There was an almost total antipathy to the Bear, largely due to its habit of killing livestock, a practice not discouraged by the fact that in new settlements, farm animals were let loose in the woods (e.g., Stewart 1806†). Sheep are the most frequently mentioned as being taken (by fourteen recorders), followed by pigs and cattle (by eight and nine recorders respectively). Not surprisingly, these attacks seem to have been greater in the early years, Stewart (1806†) recording that "the quantity of black cattle, sheep and hogs destroyed by them annually is considerable". However, later reports (Johnstone 1822†; MacGregor 1828†) suggest that such predation was only occasional, presumably due to the decline in the number of bears. Bain (1890†) also reported that bears could do "great damage" by feeding on oats in the field.

In terms of their danger to people, the general consensus was that bears avoided humans and only attacked when either threatened or with their cubs (Stewart 1806†; MacGregor 1828†; Bagster 1861†; Sutherland 1861†; Anonymous 1876†; Bain 1890†). All the same, it was the perception of the Black Bear as a *potential* danger, based on perhaps a few incidents, which greatly added to the human antipathy towards them. In fact, even in the early years the list of their "evils" was considered so great that an official extermination program was instituted in the 1790s (Vass 1987). This involved the payment of a bounty of 15 shillings per bear (a large sum at the time), and remained in effect until the 1860s. Vass (1987) estimated that between 1820 and 1861 bounties were paid on over a thousand bears. Apart from the bounty, the Black Bear provided other resources to some of the island's human population: its skin was especially valuable (MacGregor 1828†; Sutherland 1861†), and it was also a source of food for some, especially the Mi'kmaq (Johnstone 1822†), and the Acadians during their refugee years (Holland 1765†; Patterson 1770†), and seemingly for others as well (Sutherland 1861†; Bagster 1861†).

We are told a little about the Black Bear's natural diet: several writers noted that it fed primarily on "berries", "wild fruits" and "small shrubs", as well as on insects (ant hills and grubs in old fallen trees were favourite foods), and on smelts in the spring (Stewart 1806†; MacGregor 1828†; Sutherland 1861†; [Lawson] 1877-1878†; Bain 1890†). Curiously, none of the recorders mention them feeding on the island's abundant beech mast resource, for which there is evidence from elsewhere (e.g., Vass 1987; Telfer 2004).

Marten

The American Marten (*Martes americana*) occurs in nineteen of the twenty-one lists (Table 1). The only comments on its abundance are Stewart's (1806†) that it was "a very shy little animal, seldom seen in the woods, though some years in great abundance", and Sutherland's (1861†) inclusion of it among those mustelids that were "much more numerous" than the "comparatively scarce" otter. Bain (1890†) noted that it was "a woodland animal nesting in hollow trees and feeding on birds and small animals", and they also appear to have fed on voles during the "mouse plagues" (MacLeod 1876††). None of the recorders seemed aware of its approaching extirpation, for at some period, perhaps even in the late nineteenth century, the Marten became extinct on the island. As for its fur, several recorders commented on its value (e.g., MacGregor 1828†; Hill 1839†; Sutherland 1861†), while Holland (1765†) reported that martens were one of those animals that the refugee Acadians were compelled to use as food after the deportation of most of the French population in 1758.

Weasel

The first record for the presence of the Short-tailed Weasel or Ermine (*Mustela erminea*) on the island is that of Stewart (1806†) (Table 1). In fact, he treated it as two separate species, as did several later recorders. One of these he called the "weasel", which he said was "common" and "often destructive amongst poultry", while the other, the "ermine", was "uncommon" and made its nest inside fallen trees. MacGregor (1828†), continuing this distinction, said that "weasels and ermines were not common", as did Bagster (1861†), who, however, considered only one species to be present, which he called the ermine or "white weasel". In the same year Sutherland (1861†), still listing it as two separate species, said they were "much more numerous" than the otter, and that their fur "brings a fair price", which is the only comment on its value as a fur-bearing animal. Apart from Stewart (1806†) above, no other author implies that it was a pest, and Bain's (1890†) comment that it was "frequently seen about farmsteads where it comes in search of mice", indicates that it was then not uncommon, and at the same viewed as an assistant in mouse control.

Mink

The American Mink (*Mustela vison*) is first recorded in the French period (Franquet 1751†) and thereafter appears in thirteen of the British period lists (Table 1). The only comment on its abundance is Sutherland's (1861†) that it was much more numerous than the "comparatively scarce" otter. Its habitat associations are encompassed in Stewart's (1806†) description of it as "amphibious", while Bain (1890†) used the term "semi-aquatic", saying that it fed on fish and frogs, as well as on "small land animals". Bagster (1861†) also noted fish as its main food item. In terms of its pest status, both Stewart (1806†) and Bain (1890†) recorded that it took poultry and eggs, while Bagster (1861†) said that it also caused damage by burrowing into mill-dams. Several recorders reported its fur to be of value (Stewart 1806†; MacGregor 1828†; Hill 1839†; Sutherland 1861†; Bain 1890†), though Bagster (1861†) said it varied in quality.

Otter

The River Otter (*Lontra canadensis*) makes an appearance in seventeen of the twenty-one lists, beginning with that of La Ronde in 1721 (Table 1). Due to the high quality and monetary value of its fur (Stewart 1806†; MacGregor 1828†; Hill 1839†; Bagster 1861†; Sutherland 1861†; Bain 1890†), in the British period the otter was under considerable pressure from trapping, and such trapping had also been recorded in the French period (Roma 1750†; Pichon 1760†). As early as 1806 Stewart's use of the past tense: "they have been very plenty on the island" implies they were in decline, despite his adding that "they are still caught in considerable numbers". By 1861 both Bagster and Sutherland could note that otters were "getting very scarce" and "comparatively scarce", respectively, Sutherland attributing this to habitat loss, or as he put it, "the increasing occupation of the country". Bain in 1890, by which time it must have been even scarcer, if not already extirpated, makes no comment at all on its abundance, instead noting that it lived in ponds and streams feeding on fish, and that when these failed, "it will attack lambs and poultry". Holland (1765†) noted that it was among those animals hunted by the refugee Acadians for food.

Lynx

The Canada Lynx (*Lynx lynx*) was recorded by eighteen of the twenty-one list-makers (Table 1). Though it was sometimes trapped for its fur (Stewart 1806†; MacGregor 1828†; Bagster 1861†), and for food (Holland 1765†; Patterson 1774†; Stewart 1806†), it was more generally viewed as a harmful predator of farm livestock. Johnstone (1822†) said that 'wild cats' sometimes preyed on cattle and sheep in the woods, while MacGregor (1828†), Bagster (1861†) and ([Lawson] 1877-1878†) noted that it specifically attacked sheep, killing several at a time without eating them. This, however, is contradicted by Stewart (1806†), who said that "very few of them have been known to attack sheep or lambs". Given this reputation, it is not surprising that in the 1820s a bounty (of five shillings) was instituted in an effort to exterminate the lynx, and from government records, Vass (1987) estimates that 357 bounties were collected between 1820 and 1861. Given the ease with which it could be killed with dogs, or caught in snares or traps (e.g., Stewart 1806†), combined with the loss of its habitat (Lawson 1851†), it is not surprising that an animal that MacGregor (1828†) had said was "rather numerous", and Bain noted had once been "not uncommon", was by 1890 "unknown" (Bain 1890†). As for its natural foods, Stewart (1806†) said that it lived on "hares and partridges"; Sutherland (1861†) mentions "small mammals, mice, birds, rabbits etc."; Rowan (1876†) noted its predation on hares; while Bain (1890†) said it ate "small quadrupeds and birds".

Seals

The presence of seals around the shores of the island was noted by many recorders throughout the French and British periods (Table 1), but without any other information being given than that they provided a source of meat and oil to the inhabitants, as well oil and skins for export (the export of some 860 seal skins was recorded in the island's customs records between 1802 and 1807). All of the recorders write as if only a single species were present except Stewart (1806†) who distinguished between two different "kinds" of seal, one of which, he said, was "very common" in all of the rivers and harbours of the island – this presumably was the Harbour Seal (*Phoca vitulina*). The other, he said, was "a larger kind brought on the coast annually in the month of April by the floating ice from the

northward; ... sometimes vast quantities come, other years little or none". This must be the Harp Seal (*Phoca groenlandica*), and Stewart goes on to describe the hunting of them from schooners. MacGregor (1828†) and Sutherland (1861†) combine together details applicable to each of these species, without realising they were describing two separate species, Sutherland adding that by his day seals were less common than formerly.

Walrus

It is odd that French period recorders make no reference to the presence of the Atlantic Walrus (*Odobenus rosmarus*) along the shores of the island, though La Ronde (1721†) noted the presence of the '*vache marine*', as he called it, in the Magdalen Islands, to which he said they were sending a ship from the island to participate in the summer hunt. The first record of the walrus directly on the island itself is thus that of the British surveyor Samuel Holland (1765†) (Table 1), who, however, stated that they "seldom or never come on shore but are now and then killed in the spring by the inhabitants in their canoes, when they happen to float too near the shore on pieces of ice". This, however, conflicts with some of the later British records, especially that of Stewart (1806†), who claimed that in the 1770s (he himself having arrived on the island in 1775) "sea cows" had been "found in great numbers on the north coast" (he especially mentions the area near North Cape), and he added that between 1770 and 1775 they were caught in considerable numbers there, the method being to drive the herds inland and then slaughter them using long spears. However, at the time that he was writing in 1806 he said that they "are now become scarce and seldom seen ashore". All of the later historical records for the presence of the walrus are thus retrospective (e.g., MacGregor 1828†; Hill 1839†; Sutherland 1861†), and all state that it was no longer observed around the island. The animal was killed especially for its oil, but there is also mention of the value of its hide for making ropes, harness and shoes (e.g., Curtis 1775††; Stewart 1806†; MacGregor 1828†; Hill 1839†; [Lawson] 1877-1878†), as well as of its tusks for ivory (e.g., Stewart 1806†; MacGregor 1828†).

Caribou

The first record of the presence of the Woodland Caribou (*Rangifer tarandus*) on the island is that of Nicholas Denys (1672††): he said that there were only a few on account of the Mi'kmaq being too fond of them for food to allow them to increase. Somewhat in conflict with this statement is that of La Ronde (1721†), who said that the Mi'kmaq did not find the Caribou easy to kill. The last French period record of their presence is that of Roma (1750†), who had left the island in 1746. The only record of their possible survival into the British period is that of Holland (1765†) who noted that there were "some, but very few Carriboux". If the species was still present in 1765, then it would seem to have become extinct shortly after, for ten years later, in 1775, Thomas Curtis recorded that none of the inhabitants whom he had met (and one of these had been resident since 1768) knew of any "deer" on the island (Curtis 1775††). I also say "if" for Holland's record because, as has often been demonstrated elsewhere, there is a tendency for people to believe that an extirpated animal is still present long after its disappearance, so that Holland, perhaps having been told by the Acadians of its past presence in small numbers, recorded it as still present. It is also significant that he did not include them as one of the animals that the refugee Acadians hunted for food, which they surely would have done, had it been present. Thereafter in the nineteenth century, the past presence of the Caribou was witnessed by the occasional finding of a "time-worn" antler in the woods (Lawson 1851†; Bagster 1861†; Rowan 1876†), though such antlers were also sometimes erroneously cited as evidence for the past occurrence of the Moose on the island (see below).

Squirrels and Chipmunk

That squirrels occur in only thirteen of the twenty-one lists (Table 1) is an indication not of their scarcity, but that, being of little value as either food or for their fur, they tended to be overlooked, except by those who set out to list all of the island's mammals. In fact during the French period the only recorder to note the presence of any of the squirrel species was La Ronde (1721†), who recorded the elusive flying squirrel, presumably because of its unusual mode of movement. In the early decades of British settlement, although several recorders noted the presence of different "kinds" of squirrel, they did not name them. Thus it was not until 1806 that the three species currently occurring are specifically recorded: the American Red Squirrel (*Tamiasciuris hudsonicus*), the Eastern Chipmunk (*Tamias striatus*), and the Northern flying squirrel (*Glaucomys sabrinus*) (Stewart 1806†), and thereafter, all three are listed by another five recorders (Table 1).

The red squirrel and the chipmunk were considered very plentiful (Stewart 1806†; Johnstone 1822†; Sutherland 1861†), but due to its nocturnal and elusive habits there was some uncertainty as to the abundance of the flying squirrel: Stewart (1806†) considered it not as common as the other two species, though Bain (1890†) said it was "not rare". Stewart (1806†) said that all three species, and particularly the chipmunk, increased "vastly" the year after a crop of beech mast, while Bain (1890†) said that the red squirrel was "plentiful in every wood where beech nuts were found". Bain (1890†) said that the chipmunk dug its burrow "under the roots of the great trees in a spruce wood", while the flying squirrel nested in hollow trees.

Muskrat

The Muskrat (*Ondatra zibethicus*) was listed by fifteen of the twenty-one list makers (Table 1), most of whom make no further comment about it. Though Bagster (1861†) said it was "by no means plentiful", Rowan (1876†) considered it to be "very plentiful", and Stewart (1806†), Sutherland (1861†), and Bain (1890†) said it was frequently seen about streams and ponds. There were opposing opinions about the value of its pelt: Bagster (1861†) said the fur was "useful and saleable", while Sutherland (1861†) said it was "thin and poor and little esteemed". Holland (1765†) included Muskrats as one of the animals that the refugee Acadians used for food, while Bain (1890†) noted that Muskrats, due to their habit of burrowing into the banks, were "troublesome about mill dams". As for its natural foods, Sutherland (1861†) and Bain (1890†) noted that it ate roots, shellfish and seeds.

"Plague Mouse"

During the French period, as well as in the first eighty years of British settlement, virtually the only species of mouse or vole that entered the records was the one responsible in occasional years for the destruction of the settlers' crops. This "plague mouse" damaged the crops several times during the French regime (e.g., Roma 1750†; Franquet 1751†; La Roque 1752††), while during the British period there were at least eight further outbreaks between 1770 and 1815 (Sobey 2006). However, by 1828 MacGregor noted that within the previous twenty years little injury had been done to the crops by "these mischievous animals".

Identifying the species responsible for the outbreaks has not been easy. Roma's (1750†) detailed description of the habits of the vole that caused the *fléau* [plague] of 1738, appears to better fit the Southern Red-backed Vole (*Clethrionomys gapperi*), rather than the Meadow Vole (*Microtus pennsylvanicus*), which has been more generally viewed as the culprit (e.g., MacQuarrie 1987): Roma's *mulot*, as he called it, was a woodland species (this, confirmed by all of the other French and British recorders, fits only the Southern Red-backed Vole); it made substantial underground food caches for the winter; and it was able to climb (although Roma said not as well as the *souris* (probably the Deer Mouse, *Peromyscus maniculatus*). These last two properties are characteristic of the Southern Red-backed Vole as described by Hamilton and Whitaker (1979) and Godin (1977), and appear not to apply to the Meadow Vole. However, I note that Banfield (1974) states that the Southern Red-backed Vole does *not* store up food for winter, whereas he says the Meadow Vole does. Unfortunately, the subsequent British period recorders do not supply any additional information that would enable us to settle the matter: what records there are, indicate the animal was a largish "mouse" with a short tail (e.g., Patterson 1770†; Shuttleworth 1793†). Even so, the further history of the outbreaks – the fact that they occurred only during the pioneer phase when new clearings were being opened up in the forest, and ceased as the forests were cleared – points also to the Southern Red-backed Vole.

Two alternative theories were proposed for the cause of the outbreaks by contemporary observers. Roma (1750†) and Patterson (1770†) considered that winters with heavy snow gave the voles protection from their predators, at the same time allowing them to feed from their stores under the snow; whereas Franquet (1751†), La Roque (1752††), Stewart (1806†) and Plessis (1812††) considered that the high production of beech mast in certain years was the cause. It is impossible retrospectively to determine which if either of these explanations is correct.

Other mice and voles

The first mention of a mouse other than the "plague mouse" is, Roma's (1750†) reference above to the *souris* [mouse] that he said was a better climber than the plague vole – this can only be the Deer Mouse. The next mention is over a century later: Sutherland (1861†) refers to two species of "field mice": the "burrowing field mouse", which appears from his description to be the Meadow Vole, and the "leaping field mouse", which, given its "long tail and strong hind legs", is likely to be the Meadow Jumping Mouse (*Zapus hudsonius*). Sutherland did not realize that there was another species of jumping mouse on the island, the Woodland Jumping Mouse (*Napaeozapus insignis*), first recorded by Cameron (1958).

The only other recorder to distinguish between the native species of mice and voles was Bain (1890†) who listed three native species: his "short-tailed Meadow Mouse" can only be the Meadow Vole since his brief description fits this species: "it lives on grain and grasses, and builds a nest of dry grass and makes long galleries under the snow in winter when it causes much destruction by barking young orchard trees". His two other species were "much less common": his "White-Footed Mouse" can only be the Deer Mouse, while his "Hamster Mouse" must be the Southern Red-backed Vole. He thus did not record either species of jumping mouse.

Snowshoe Hare

The Snowshoe Hare (*Lepus americanus*) is listed by all but two of the list-makers (Table 1), with many of the recorders noting that hares were abundant on the island. The only recorders to give any information on its habitat are Rowan (1876†), who said "their favourite resort is the second growth of young forest", and Bain (1890†), who noted they liked "dry ground in summer but frequent the swamps in winter". This was presumably related to the food they fed on in winter, which Bain (1890†) said was "young shoots of trees" – these were more specifically identified by Rowan (1876†) as "the tender twigs of maple, moosewood, birch, willow, alder etc.". Both recorders said

that in summer they fed on "grass". Rowan said that on the island their natural enemies were the Lynx, Marten, Weasel and Fox, as well as birds of prey, and man. Almost all of the recorders refer to the Snowshoe Hare in the context of a game animal, and in the early years of settlement it seems to have been an important supplementary food source for the human population (e.g., Curtis 1775††; Chappell 1775-1818††). Hares continued to be eaten throughout the nineteenth century and were considered a delicacy by many. However, Johnstone (1822†) and Sutherland (1861†) considered their fur to be of little value.

Absences in the records

Moles

Although Johnstone (1822†) stated categorically that "there is not a mole on the island", two later writers of school textbooks for the island (Sutherland 1861†; Bain 1890†), included it in their lists of the island's mammals, both using similar phrasing: "it burrows in the ground and lives on worms". Despite their assertions, there is no evidence that a species of mole has ever occurred on Prince Edward Island, and neither Cameron (1958) nor ACCDC (2008*) have included it in their lists of the native mammals.

Fisher

The Fisher (*Martes pennanti*), which currently occurs in Nova Scotia and New Brunswick, is entirely absent from the historical records for the island. Thus the inclusion of Prince Edward Island in the animal's historical range by Cameron (1958), Peterson (1966), Banfield (1974) and ACCDC (2008*) is not supported by the early records.

Moose

There is no historical evidence that the Moose (*Alces alces*) ever occurred on Prince Edward Island, at least during the settlement period, and in fact there is strong evidence to the contrary: during the French period Denys (1672††) and La Ronde (1721†) had made a point of recording that the Moose was absent from the island, as did Sutherland (1861†) during the nineteenth century. The five British period records of its occurrence are late and retrospective (Table 1), and are all based on the anecdotal finding of "moose horns" in the woods – it was this evidence that led Cameron (1958) and Banfield (1974) to list the Moose as once occurring on the island. These "horns", however, are far more likely to have belonged to the Caribou, for which there is irrefutable evidence of its past occurrence.

Beaver

The only historical record for the occurrence of the American Beaver (*Castor canadensis*) on Prince Edward Island (that is, prior to its deliberate introduction in the twentieth century) is that of Bain (1890†) who said that it was "once common here and the remains of its dams are still to be seen in many parts of the country". This is a curious statement since fourteen years earlier Rowan (1876†) had said that he had not seen or heard of any "beaver works" on the island, and so he was "inclined to think" they had "never lived on the island", as "their traces endure long after they have become extinct". So also had Sutherland (1861†) included it in a list of the mammals found on the mainland that did *not* occur on the island. The validity of Rowan's and Sutherland's observations is strongly supported by the fact that its absence from the island had been noted at the beginning of French settlement by La Ronde (1721†), as well as by the fact that none of the other list-makers had included the beaver in their lists of the island's mammals, including Stewart (1806†), Johnstone (1822†) and MacGregor (1828†) who had made fairly comprehensive lists. Given the commercial importance of its fur and its relatively large size, it was a mammal that, had it been present, would not have been overlooked. Apart from Bain's comment, the only other mentions of the beaver that I have come across in the historical records are its inclusion in a list of the retail prices of pelts, printed in a pamphlet for immigrants to the island (Anonymous 1808††), and the presence of beaver pelts among a consignment of animal skins shipped to Halifax in 1802 (Sobey 2006). Since pelts were easily transportable from the mainland, where the species did occur, neither record indicates its presence on the island. It should be noted that the beaver's absence from the island from 1720 onward does not exclude the possibility that it had been trapped-out prior to the eighteenth century. The evidence in support of such a view, however, is limited to the finding of a beaver incisor tooth in an archaeological dig at a prehistoric aboriginal site (probably Mi'kmaq) near East Point that was occupied from about 800 to 1000 AD (Keenlyside 1983) (though such a small item could have been easily carried from the mainland), and the unreferenced statement of Cameron (1958) that beaver tooth-marks had been found on sticks from island peat-bogs.

Other absences

Sutherland (1861†) noted the absence of the Raccoon (*Procyon lotor*) from the island, as well as the American Porcupine (*Erethizon dorsatum*) (as had La Ronde IN 1721†), both of which he noted as occurring in Nova Scotia and New Brunswick; while Rowan (1876†) noted the absence of the "Virginian deer" (i.e., the White-tailed Deer, *Odocoileus virginianus*). The validity of these statements is supported by the fact that none of these animals was noted as present by any other of the historical recorders.

Discussion

The island's native mammalian fauna

Thirteen of the island's native terrestrial mammals were recorded by French period observers (Table 1),

with British period recorders taking the total to twenty. On the basis of the current ACCDC (2008*) mammal list for the island, we may surmise that the number of terrestrial species at the time of settlement might have been 28. This includes my deletion of the beaver and Fisher from the ACCDC list, and ignores the post-settlement arrivals of the Brown Rat (*Rattus norvegicus*), House Mouse (*Mus domesticus*), Striped Skunk (*Mephitis mephitis*), Racoon and Coyote (*Canis latrans*), the latter three in the twentieth century. The eight omissions from the historical record are all small mammals: the island's five species of shrew (assuming those currently in the ACCDC list were also present in the eighteenth century) were treated by the early recorders as one species, as were the four species of bat; while one of the five species of native mice and voles went unrecorded (the Woodland Jumping Mouse *Napaeozapus insignis*, first recorded by Cameron 1958). As for the marine fauna, three species are distinguished in the historical records: the Walrus, and seemingly, the Harbour Seal and Harp Seal. Thus the two other seal species listed by ACCDC (2008*) as currently occurring in the Gulf of St. Lawrence (the Grey Seal, *Halichoerus grypus* and Hooded Seal, *Cystophora cristata*) are not discernable in the historical records for the island.

Despite the absence of three key boreal elements from the records (the Moose, porcupine and beaver), the terrestrial fauna recorded at the beginning of European settlement is a boreal fauna, signalled in the records by the presence of the Snowshoe Hare, Red Squirrel, Northern Flying Squirrel, Southern Red-backed Vole, American Marten, Short-tailed Weasel, Canada Lynx, and Woodland Caribou. All of the other mammals recorded (e.g., the American Black Bear, Grey Wolf, Red Fox, American Otter, Mink and Muskrat) are also quite at home in the boreal forest zone, though occurring widely in more southerly areas as well (e.g., Banfield 1974; Hall 1981). Concomitantly, there is a total absence of mammals characteristic of the more southern deciduous forest zone (e.g., the Striped Skunk, Racoon, Eastern Grey Squirrel, *Sciurus carolinensis*, and White-tailed Deer); and if Denys (1672††) is to be relied upon, none of these were present in the rest of Acadia (including eastern Maine) in the seventeenth century – though in the last two centuries such southern species have reached the adjacent mainland and some have even been introduced onto the island (i.e., Striped Skunk and Racoon).

The presence of the Woodland Caribou, along with its predator, the Grey Wolf, is one of the more interesting pieces of information to emerge from the records of the period, and is a corrective to Lohr and Ballard's (1996) statement that wolves never occurred on Prince Edward Island. As I have noted, it seems that neither species was abundant, and La Ronde (1721†) said that the reason the Mi'kmaq did not spend the winter on the island was that they found the Caribou difficult to kill (he actually called them *cerfs* or "deer"), the implication being that there was little else for them to eat in winter – which would indeed have been so, given the absence of the beaver and the Moose, two of their traditional winter food animals (e.g., Denys 1672††). We thus have here a clear instance of the natural fauna (both presences and absences) having important effects on the aboriginal population.

The importance of the beech forests

The historical evidence indicates that American Beech was a very important tree in the upland hardwood forests of the island, with large areas of the land surface being covered by beech forest (Sobey 2006). Beech produces a nut (traditionally called mast), which provides an important food for many different animals (e.g., Tubbs and Houston 1990). In the historical records for the island we are told, as we have seen, that the Red and Flying squirrels, the chipmunk and the "plague mouse" fed on the mast, as also, we may presume, did all of the other woodland mice and voles. Evidence from elsewhere (e.g., Vass 1987; Telfer 2004) indicates that the American Black Bear was also likely to have done so.

The North American Beech has long been known to be irregular in its seed production, with "mast years" occurring every two to eight years (Tubbs and Houston 1990). That the beech forests on the island also exhibited such mast years is recorded by Franquet (1751†), La Roque (1752††), Stewart (1806†), Plessis (1812††) and Bain (1868-1884††). As we have seen, such mast years were considered by some to be the cause of the vole irruptions, while Stewart (1806†) said that the three squirrel species (and of these, especially the chipmunk) also showed a "great increase" in numbers "after an abundant crop of beech mast". And though they did not enter the written record, we may presume that all of the other feeders on beech mast would also have been affected. As well, the distribution of beech forests on the island might have affected the spatial distribution of the mast-feeders, and this may not have been only in mast years. However, the only evidence that we have for this is Bain's (1890†) comment that the red squirrel was "so plentiful in every wood where beech nuts are found".

Given this recorded increase in the mast-eaters, we might expect that the island's predator populations might have concentrated on them when they were abundant – Roma (1750†) had certainly noted that the fox and the marten fed on the voles during a plague year. We have a hint that this abundance of prey may have also led to a increase in the *numbers* of the predator species, in Franquet's (1751†) statement that foxes, martens, mink and lynx were more abundant in some years than in others, as well as Stewart's (1806†) that the marten was in "great abundance" in some years. However, confounding factors here are the so-called "long" or "nine to ten year cycle" in the numbers of the Snowshoe Hare and its predators (especially the

lynx) that has long been recorded throughout its North American range and the "short" cycle (of two to three years) that commonly occurs among rodents and their predators in northern environments (e.g., Finerty 1980).

We can only speculate on the effect that the great decline in the area of beech forest has had on the ability of the forests to sustain the food-webs that they did before European settlement. Prior to forest clearance, beech was a predominant tree, Stewart (1806†), for example, saying that "one-half of the island is covered with it, in some districts it forms nine-tenths of the forest". By 1991, however, beech contributed only 4.1% of the woody biomass in the remaining upland hardwood forest (Sobey and Glen 2002), and far less when all of the forest-types are considered. Thus those mammals still occurring on the island that were once substantial mast-eaters (the chipmunk, squirrels, voles and mice) have had to turn to other types of food.

The utilization of the mammalian fauna for food and fur

All of the French period mentions of the Caribou refer to it in the context of game, either for the aboriginal Mi'kmaq (Denys 1672††; La Ronde 1721†) or the new French settlers (Gotteville de Belile 1720††; Roma 1750†). Then, after the Caribou's extirpation in the mid-eighteenth century, the animal most mentioned as a source of food is the Snowshoe Hare. As well, other animals that most people nowadays would not consider edible are also recorded as being eaten by the European population, notably the bear and the lynx, while Holland (1765†) reported that the refugee Acadians were eating even martens, otters and Muskrats. The island's seals also served as food for the Acadian population in the early years (La Ronde 1721†; Roma 1750†; Patterson 1770†), as did oil from the walrus (Stewart 1806†). However, once settlement was established, the native fauna seems to have become unimportant as a food source, though the hare continued to be mentioned as a game animal throughout the nineteenth century.

Would the hunting of any of these animals for food have had any effect on their numbers? It is probably not a coincidence that the Caribou disappeared from the island within a few decades of the establishment of the first permanent settlement in 1720: the small numbers reported to occur (e.g., Denys 1672††; Holland 1765†) would have been vulnerable to even low levels of hunting. Also, the hunting of the walrus for its oil may have contributed to its disappearance from island waters. By contrast, the Snowshoe Hare continues to thrive on the island, and any hunting, even in the unregulated early days, seems to have had little effect.

As for those animals that served as food only under extreme conditions, it is clear that hunting was another pressure that contributed to their extirpation, namely, their being hunted for their furs. However, though many recorders, as we have seen, stress the value of the furs of the otter, marten, mink, Red Fox, and black bear, and to a less extent the lynx and the Short-tailed Weasel, concrete data on any fur trade that developed on the island is sparse in the historical record. For the French period, the only specific references are Roma's (1750†) comment that "*la chasse aux martres* [i.e., marten-hunting] should be reserved to the Mi'kmaq to enable them to "procure their needs", and the entry in the 1757 journal of an officer aboard a French warship at Louisbourg that "the Indians of Île Saint-Jean usually come to Louisbourg in August and September to sell their animal pelts which brings them a very good profit" (Sobey 2006).

In the British period, the only recorder to give the fur trade more than a passing mention is Samuel Hill (1839†), who wrote that "there was once a considerable export of furs from the island". The island's customs records contain evidence of two such early fur shipments: the *Betsy*, bound for Halifax in June 1802, had amongst its cargo "4 Trunks of furs, containing Rabbit, Fox, Martin, & Beaver skins, a few seal skins & 30 Dozen loose rabbit skins"; while in May 1819 the *Nelly*, also bound for Halifax, had 1200 "rabbit" skins, 162 martin, 14 otter, 1 lynx, and 1 bear. (The presence of beaver skins in the 1802 shipment indicates that at least some of the furs had come from the mainland.) Also, the inventory of the estate of one John Rennie in 1791 recorded that at his death he was in possession of "six dozen dressed marten skins" (Nicholson 2004).

When Hill goes on to comment on the fur trade of the 1830s he highlights the role of the Mi'kmaq: "foxes are chiefly shot or trapped by the Indians, and their skins exported to England by the resident merchants", and other writers also refer to the skills of the Mi'kmaq in the trapping of the native fauna (Johnstone 1822†; MacGregor 1828†). And there is also an 1830s record of the export of furs in the customs records: the *Catherine Jane* bound for Liverpool in May 1834 carried 493 fox pelts (of which 19 were cross and 4 silver), 440 marten, 60 "rabbit", 40 lynx, 31 otter, 29 mink, 2 Raccoon, and 1 Muskrat. As was so for the beaver above, the presence of the two Raccoon pelts indicates that some of the skins must have come from the mainland, since the Raccoon is otherwise absent from the historical records for the island.

Extirpations among the fauna

Four of the fur-bearers were eliminated from the island: the marten, otter, lynx and black bear, as were also the caribou and the wolf – as well as the walrus from the waters around the island. We may question whether all of these extirpations were inevitable. Granted that the large-scale destruction of forest to make way for farmland would have resulted in a considerable loss of habitat and a resulting decline in the total numbers of all of the terrestrial mammals; even

so, with the exception of the caribou and the wolf, which are both likely to have required a greater area of forested habitat than what remained, the other four land mammals should have been able to survive in the remaining areas of forest and other habitat. In the British Isles the Pine Marten (*Martes martes*) and European Otters (*Lutra lutra*) have been able to survive in landscapes greatly altered by human activity, and in association with as high or even higher human population densities than on Prince Edward Island (e.g., Corbett and Southern 1977; Jefferies 1989). It thus seems that had there not been the uncontrolled trapping of the marten – an animal notoriously easy to trap (e.g., Banfield 1974; Hamilton and Whitaker 1979) – it very likely could have survived. As for the Otter, though habitat loss may have played a role, the rivers and bays that were its habitat being directly adjacent to the areas first selected for settlement, unregulated trapping appears also to have been the main reason for its extirpation. In fact, it was not until 1879 that the island's House of Assembly passed its first act "for the protection of Game and Fur-bearing Animals", which, among other measures, restricted the season for taking Muskrat, marten, and otter to between 1 November and 1 May (Glen1995).

As for the lynx and the black bear, had there not been active hostility towards them, including the institution of bounties, it is possible that they could also have survived. According to Anonymous (2003*), "as long as they are not disturbed", lynx are "remarkably tolerant of human settlement" (see also Poole (2003)), while the last bear on the island was shot as late as the 1920s – some forty years after the peak of human population density. As for the Walrus, though the island's first British governor was aware of the need for controls on the "sea cow fishery" and even had his council pass an ordinance in 1770 to regulate it, he was aware that the hunt, being largely carried out by "vessels from New England", was beyond the control of his infant government (Patterson 1774†).

We may thus conclude that though the *activities* of the settler population led to the seven extirpations, an important factor contributing to four of them was the *attitude* of the settlers: a positive hostility to the lynx and the bear (understandable in the light of their predation on livestock), and an indifference to the survival of the otter and the marten so that the necessary protections were not instituted until it was too late.

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Social and Play Behavior in a Wild Eastern Coyote, *Canis latrans*, Pack

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I had close and consistent observations of a wild eastern Coyote pack (*Canis latrans*) from January 2000 to August 2007. During this time, I obtained 3156 radio-locations on a specific radio-collared breeding male ("Sill") and observed him and/or members of his pack on 375 occasions. The average group size = 3.0 ± 2.3 (SD) Coyotes with 1.9 ± 1.2 (SD) being adults and 1.1 ± 1.9 being pups. Maximal group size involved 12 Coyotes (9 pups, 3 adults). During these observations, Coyotes most often behaved in a friendly manner toward each other as indicated by 80 of my observations involving play between pups, and 15 involving play among adult Coyotes. On the evening of 6 July 2007 I observed the breeding male (>8 yr old), his mate (>5 yr old), one of their full-sized probable yearlings, and five pups playing intensely for 33 minutes. This paper details social and play behavior from this pack, especially from the 6 July 2007 observation.

Key Words: *Canis latrans*, eastern Coyote, amiable/affiliative interactions, play behavior, Massachusetts.

Although not exclusively a mammalian trait, play is an important social activity for mammals, and especially for carnivores (Bekoff 1972a, b, 1989; Ewer 1973; Rennicke 2007). It is characterized by (1) friendly, non-aggressive (or amiable) intentions; (2) more energy than is strictly necessary; and (3) a typical air of eagerness, excitement, and enjoyment during interactions (Ewer 1973; Bekoff 1974a, b, 1989). Although play is not unknown in adults, it is displayed more commonly in young animals (Bekoff 1978), and provides the means of doing all the things the central nervous system is prepared for without any of the risks inherent in a "real" (e.g., hunting, fighting) situation (Ewer 1973). Hypotheses about the function of play in canids have been reviewed by Bekoff (1974a) and Packard (2003) and include (1) the ability to learn counter-tactics during play that may provide a basis for learning complex social relationships later in life; (2) physical exercise related to aerobic conditioning; (3) development of muscular routines; (4) practice of instincts useful for hunting later in life; (5) a demonstration that "animals that play together, tend to stay together"; i.e., social cohesion; and (6) an indication that it may simply be fun and a pleasurable experience.

In the vast majority of studies on Coyotes (*Canis latrans*) (and on carnivores in general), play behavior has occurred with juveniles in captivity where researchers can easily observe their study subjects and quantify behavioral observations in a controlled setting (Bekoff 1972a, 1974b, 1978, 1989; Way et al. 2006). Packard (2003) noted that our understanding of Wolf (*Canis lupus*) social behavior will advance more rapidly when we integrate the information from both captive and field populations, as long as we take great care to recognize the limitations of each perspective and to understand the whole as the sum of the parts. However, few studies have examined the play of Coyotes and Wolves in the wild (Ortega 1988; Mech 1997; Packard 2003). Of these studies, all detailed play behavior was observed only in pups.

For instance, Mech (1997: 75) watched wild Wolf pups in the Arctic play "for about 45 minutes as the pups scrambled back and forth across the snowfield, chasing one another, tackling, sliding, rolling, skidding, and carrying on to a degree I have never seen nor heard of before for any species." Observations of pups playing is a common theme in studies on play behavior in canids, and despite some authors claiming that adult canids play (e.g., Bekoff 1989; Lehner 1978; Packard 2003), there is scant evidence of this in the wild, possibly due to their need for conservation of energy, certainly in harsh climates. In this paper I describe a social, amiable, wild Coyote pack, including observations of the older adults in the pack playing.

Methods

Research was conducted in an urbanized area (town of Barnstable on Cape Cod) in eastern Massachusetts (see Way et al. 2001, 2002a, 2004). Average human density on the study site was 290 people/km^2 and road density was 4.66 km of roadway per km^2 (Cape Cod Commission 1998*). Observations began on 18 January 2000 when the Coyote "Sill" (ID # 0003), a 16.8 kg 9-month old male Coyote was captured in a box trap (model 610B, 152.4 cm × 50.8 cm × 66.0 cm, Tomahawk Live Trap Co., Tomahawk, Wisconsin, USA: Way et al. 2002b) in Cotuit (within the town of Barnstable), Massachusetts, and radio-collared as part of an ongoing study of eastern Coyote ecology on Cape Cod (Way et al. 2002a, 2004). Sill was tracked on his natal range (his father, "Kett," ID # 9805, was also radio-collared) until January 2001 when he dispersed

and settled into a vacant territory to the immediate east of his natal range in February/March 2001 (see Way 2007* for more details). He was the dominant male of that new pack (Newtown/Bog Pack) in Marstons Mills (within the town of Barnstable) from 2002 to 2007, when the study ended.

Tracking protocols were fully described by Way et al. (2002a, 2004). Portable receivers (Custom Electronics, Urbana, Illinois, USA) and hand-held 3-element Yagi antennas were used to radio-track Coyotes both on foot and from a vehicle. Animals were typically homed in on using the loudest-signal method of radio-tracking (Springer 1979). I approached radio-collared Coyotes as closely as possible without disturbing them. I used binoculars, 15-45 × spotting scopes (Bushnell, Overland Park, Kansas, USA), and video-cameras when observing Coyotes at den and rendezvous sites (Way et al. 2001, 2003), and spotlighting and headlights when following Coyotes at night with a vehicle (Way et al. 2002a, 2004).

Collared Coyotes were often seen with untagged companion(s), especially when at rendezvous sites (Way 2003). A detailed description (e.g., size, coloration, distinguishing markings, and behavior) of the uncollared animals was made during every direct observation. In this manner, the unmarked Coyotes were identified based on appearance, as described by Way et al. (2002a) and Way (2004). Overall, I identified as many Coyotes as possible from Sill's pack, as well as from other groups within the study area. I classified Coyotes as adults or pups/juveniles. Adults were classified as all full-sized Coyotes and often included yearlings that remained on their natal territory. Pups were born in April (Way et al. 2001) and were classified as such until October, when they approached full body size and became indistinguishable from adults when observed in the field. Due to the logistic difficulties of keeping track of large groups (≥5) of Coyotes observed at the same time (especially when they temporarily separated and were all visible at the same time but only one observer was there to monitor them in separate locations), it was necessary to began with this simple coding scheme (pups or adults).

Most of the lengthy sightings were made at two sets of cranberry bog complexes (2-3 bogs at each location; complexes were 1 km apart) where distant (~400 m) viewing was possible (Way 2003, 2007*). Sill's pack began using these bogs in summer 2003 following the death of an old female Coyote ("Mole" #0110) in the pack to their immediate northeast (Way and Strauss 2004; Way 2007*). To avoid autocorrelation (see Way et al. 2004), sightings were separated by > 4 h from each other. Typically this meant that Coyotes were observed during dawn and/or dusk on a given day with occasional daytime observations (n ~25).

Play was defined as the behavior that was performed during social interactions in which there was a decrease in social distance between the interactants, and no evidence of social investigation or of agonistic or passive-submissive behaviors on the part of the members playing, although these actions may occur as derived acts during play (e.g., passive submission during a play bout – Bekoff 1972a, 1974a; Way et al. 2006). Bekoff (1974a) classified play as (1) incorporating various contexts into unpredictable temporal sequences; (2) preceded by a metacommunicative signal (e.g., play initiation); (3) repeated and performed actions in an exaggerated manner; and (4) appearance of being pleasurable to the participants, e.g. a play face (wide open jaws and eyes) is apparent. Included in play were numerous role reversals where more dominant Coyotes allowed lower ranked Coyotes to pin them to the ground; this was never documented during agonistic displays (Way et al. 2006).

I used continuous animal sampling (Martin and Bateson 1986) to record Coyote activity and recorded the behavior (via scan sampling) of as many Coyotes concurrently as I could during my observations. I recorded data into a field notebook and video-camera for later analysis.

Results

I obtained 3156 radio-locations on Sill and observed him and/or members of his pack 375 times (>4 hours apart) from January 2000 to August 2007. The average Coyote group size during the 375 sightings was 3.0 ± 2.3 (SD) Coyotes with 1.9 ± 1.2 being adults and 1.1 ± 1.9 being pups. Maximal group size observed during an observation involved 12 Coyotes (9 pups, 3 adults), while two sightings involved 10 Coyotes (3 adults and 7 pups) and eight sightings involved 9 Coyotes (ranging from 2-7 adults and 2-7 pups). This pack was typical of other eastern Coyote social groups (see Way et al. 2002a, 2003) in that Sill had a mate ("Mange-back", positively identified from 2004/2005 to 2007, having a distinct missing patch of fur on the top of her neck and a large softball-sized bleached-like looking mark on her left rib which looked like a distinct blonde splotch on an otherwise brown body) and those two comprised the breeding pair while the remaining adults appeared to be yearlings, or pack associates, most likely their offspring from the previous year. On any given year there were 3 to 5 adults (including associates/yearlings) and four or more pups. Sill's group was especially visible for the four and a half years from 2003 to 2007 when they adjusted their territory to include two complexes of several cranberry bogs each, formerly used by a pack to their northeast. Although many of the sightings were temporary (e.g., one or two Coyotes observed for 1-2 sec while crossing a road at night), 160 (42.7%) observations occurred at rendezvous sites averaging 44.5 ± 31.4 (SD) min (maximum bout = 142 min) in duration. These rendezvous site observations produced all of the observations of play detailed below.

Coyote pups often played with each other during observation bouts (n = 80) at the rendezvous sites, which consisted of chasing, wrestling, and self-play (Way et al. 2006). It was very apparent when they were playing because role reversals often occurred where small pups pinned larger, more dominant ones (Rennicke 2007). Also, chasing often involved different combinations of chaser(s) and chasee(s) where close observations indicated open (sometimes panting), relaxed mouths. In all observations, colleagues, some of my students, or the general public (I usually observed from a main road and people frequently stopped to observe with me) agreed with my assessment of play rather than another behavior (e.g., agonistic). On 15 occasions, I observed adult Coyotes play with one another. These were frequently games such as group-chases or wrestling matches where pups also became involved. The only negative interactions that I observed between adults was when one probable yearling pinned another (n = 9 observations). I did not observe any aggressive acts directed toward Sill or his mate "Mange-back" but on four occasions Mange-back aggressively pinned another (probable female) Coyote into a passive submission posture. Based on subsequent observations, these Coyotes were likely her yearling daughters.

Sill was a very diligent father and often returned to the rendezvous sites throughout the year. Many of my observations consisted of him and 1-2 others (usually adults) returning from patrolling their territory at night to joining other Coyotes waiting at these sites (i.e., full-sized pups). During the summers of 2005 to 2007, when I positively identified Mange-back as his mate, I more often saw Sill (80% of sightings) at the rendezvous sites (July-October) with the pups than Mange-back (~60% of sightings involved her). All Coyotes acted submissive to Sill except for Mange-back, who rarely interacted with him, likely because of their familiarity with one another. Yearlings (n = 20 sightings) and pups (n = 75) often greeted Sill in an active submission posture which involved repeated licking of his mouth with exaggerated tail wagging by the intended recipient (Way et al. 2006). Sill frequently regurgitated (n = 10-12 observations) to pups when solicited, especially when returning to the rendezvous sites from surrounding areas. In fact, the only negative (agonistic) interactions I observed was when Sill growled at persistent pups (n = 10-12 observations) who repeatedly tried to lick his mouth to try stimulating him to regurgitate. All of the factors detailed herein indicated that Sill was the breeding male of a large, very successful, and amiable eastern Coyote pack.

The evening of 6 July 2007 produced the most memorable observations of amiable and play behavior from this pack. For 33 minutes I observed three adults (out of four in the pack at the time) and five pups from the pack (one of which was later hit and killed by a car on 20 July), including Sill (8 years, 3 months old at the time), Mange-back (likely >5 years old), and a yearling male named "White-band" (for a white band running laterally on his tail just posterior to the base) that was the same size as Sill. They were at the northern-most area of the two rendezvous sites (north of the site from Way 2003). At 20:15, I arrived at the rendezvous site and immediately saw eight Coyotes about 250 m NW of my location on Bog Road in Marstons Mills. They were at the junction between the northwest part of the east bog and northeast part of the middle bog (three bogs comprised this area west of Bog Road) in an open sand flat (about 25 × 20 m) dubbed "Olivia's" (O) flats for a homeowner's walking trail that leads southeast to this location ~75 m from her house.

When I arrived, I immediately set up my tripod and spotting scope as the pups were particulary active and running back and forth playing, both play chasing and play wrestling (see Way et al. 2006). At 20:20, Sill walked west about 50-75 m and bedded in sit1 alert position (Way et al. 2006) on a small (1.5 m high) mound of sand, next to a small shed/pumphouse just north of the northcentral part of the central bog. He sat alert and watched the other seven Coyotes from a distance until 20:25, when Mange-back led the five pups to the sand mound where Sill was sitting. To get the pups there, she turned around and faced the pups and took a few steps toward them until they followed her. I was too far away to hear if she called them over or if they just followed her, but she did that two or three times before completing the short trip. White-band followed the group west to the sand mound.

After trotting to that location (~15-20 sec.) the pups immediately re-engaged in intense bouts of play chasing and play wrestling. Sill greeted a couple of the pups by licking them but mostly stood up when the group arrived and then proceeded to watch them. At ca. 20:30, Mange-back, which was watching the pups play for ca. 2-3 min, got into the games by pinning a couple of pups. She had a noticeably relaxed play face (Bekoff 1974a, 1974b; Lehner 1978) and jumped back and forth as a couple of pups chased after her. Sill and White-band watched the actions right on the mound and despite pups bumping into Sill, he maintained his vigilance by surveying the area for danger.

At 20:32 Sill became active. He gathered a couple of pups, then trotted east back to the O flats. Mange-back and White-band followed him. Immediately upon approaching the O flats, he did a play bow (Way et al. 2006) to initiate play from the two pups. The pups immediately responded by chasing him and he, like Mange-back on the sand mound, stayed contained within a localized area (the O flats) instead of running from the pups as he sometimes did to get away from them. In other words, it was obvious during this particular observation that he was purposefully playing with the pups.

For the next 10 min, Sill engaged in vigorous bouts of play chasing with groups of two to three pups at a time, after the other three pups returned to the area as well. The action occurred quickly, but I believe that

he played with all five pups by the end of the session as pups were constantly changing directions and conspecifics with which they interacted. I could easily see Sill's tail wagging and his mouth open and relaxed, similar to the pups when they played. By 20:40 it was nearly dark and becoming difficult for me to see, but at this point all of the Coyotes gradually diminished their activity except for White-band which did not engage in play on that particular night. He often baby-sat the pups during summer 2007 and may have felt the need to watch them instead (although I did observe him ≥ 4 times playing with the pups that summer).

At 20:42 Sill trotted at a steady pace southwest on a canal separating the east and central bog, leaving the pups at the O flats area. When he got to the south edge of the canal (~200 m) he approached the north edge of a private property that has a ca. 40 kg Labrador/Golden retriever Domestic Dog mix ("Kota") with which he commonly interacted (by growling and barking at each other, usually from opposite sides of the bogs) south of the southeastern part of the central bog. When Sill approached the edge of Kota's yard (Kota was not outside) he sniffed then raised-leg urinated on a bush followed by a ground-scratch, common behavior I observed from him when marking his territory. He then proceeded to trot west at the south part of the bog complex, displaying a noticeably different and more serious disposition than when he was playing with the pups. He kept his tail at a 45° angle and was very alert and tense on his route west. At 20:44, Mange-back and White-band left the pups and trotted through the central bog in the general (southwest) direction of Sill, but taking a more northerly counterclockwise route, likely to avoid Kota. All three adults gradually made their way to the south part of the west bog west of Bog Road and eventually became too difficult to see at 20:48. Sill's signal (at 20:58) indicated that he continued south, crossed a secondary road (River Road), and went to the south of the two cranberry bog rendezvous sites (detailed in Way 2003). Meanwhile, the pups remained around the O flats, eventually heading northeast into the wooded patch where they commonly rested and hid. I departed the area at 20:50 at dark.

Discussion

This Coyote social group behaved in a remarkably friendly manner toward one another and similar to what has been described for Wolves, other than that they preyed on small animals (rodents, rabbits), trash and other human food, and domestic cats (J. Way, unpublished data) rather than large ungulates (see Mech et al. 1998; Mech and Boitani 2003). In fact, it was obvious to me that the Coyotes, including adults, were having fun when they played, as demonstrated by such characteristics as a play face, tail-wagging, and/or engaging in affiliative activities which have been purported as nothing but play (Bekoff 1972a, 1974b; Packard 2003; Way et al. 2006). Such canid play characteristics are obvious and recognizable to dog owners when their pet dogs are playing.

Bekoff (1999) claimed that social play may provide more promising evidence of animal minds than research in many other areas, for it may yield clues about the ability of animals to understand one another's intentions. While watching Sill, it was difficult for the pups (and for me as an observer) to misinterpret Sill's intentions from play bowing to initiate play, to a more serious (tail at 45° angle) posture when he departed for his nightly travels (when none of the pups attempted to follow him). It is highly likely that the success of this social unit was predicated on the stability of the pack members, mainly Sill and Mange-back. By being mature older adults and extremely familiar with the area (see Way 2007*), these two Coyotes were never observed getting challenged by their younger, less experienced offspring.

This particular area (i.e., the open cranberry bog complexes) has produced some memorable Coyote sightings, including observations of Coyote pups for 11 years in a row (1997-2007: see Way 2003, 2007*). However, I do not believe this group to be the exception to the norm. Other packs in my study area, although less visible on the average, have similar social units and were occasionally observed in comparable amiable scenarios where adults were seen playing with one another (e.g., see Way 2001* and Way 2007*). Many of these observations of friendliness/play included older adults (usually radio-collared) which, like Sill, probably provided stability and experience to their pack. The eastern Coyote's family-oriented nature cannot be understated. In one instance, I have even observed two adults in a Coyote pack raising pups when an older, breeding female was killed when the pups were young (Way 2004).

Due to its success, the Coyote is typically maligned by the public and is often treated as vermin or pests by state wildlife agencies and/or animal control/pest agencies (Way 2007*). However, Coyotes are highly social, family-oriented, caring animals (Camenzind 1978; Bekoff and Wells 1980; Gese et al. 1996; Crabtree and Sheldon 1999;) that probably even enjoy life and each other (Way 2007*; this study). Once thought to be too subjective, there is a growing body of literature that supports this statement (e.g., see Bekoff 2002, 2007), and data from this paper regarding this one pack studied over eight years (2000 to 2007), provides irrefutable corroboration of Coyote sociality, including amiable/affiliative behaviors such as play.

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Biologie et situation de la Lamproie du Nord, *Ichthyomyzon fossor*, au Québec

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La Lamproie du Nord est une espèce propre à l'Amérique du Nord et elle ne se rencontre, au Québec, que dans l'extrême sud de la province. Cette lamproie a été observée dans le fleuve Saint-Laurent ainsi que dans 11 de ses tributaires. Elle aurait disparu de la rivière Yamaska où elle avait été recensée entre 1946 et 1959. Poisson non parasite, sa taille au stade adulte ne dépasse habituellement pas 160 mm. Les larves, appelées ammocètes, et les adultes ne se retrouvent qu'en eau douce. Les cours d'eau utilisés sont généralement des ruisseaux et des rivières à fond graveleux ou sablonneux. La Lamproie du Nord requiert deux habitats distincts, soit un pour les adultes reproducteurs et un autre, le long du même cours d'eau, pour le développement des ammocètes. La détérioration de l'habitat et la pollution des eaux représentent les principales menaces à la survie des lamproies. La faible fécondité et la mobilité réduite de la Lamproie du Nord font en sorte que cette espèce est peu adaptable aux modifications de son environnement.

Mots-clés : Lamproie du Nord, *Ichthyomyzon fossor*, Petromyzontidae, rapport de situation, Québec.

The Northern Brook Lamprey is endemic to North America. In Quebec, it is restricted to the southernmost part of the province. This lamprey is known from the St. Lawrence River as well as in 11 of its tributaries. It appears to have been extirpated from the Yamaska River where it was collected between 1946 and 1959. It is a nonparasitic fish and its adult size does not usually exceed 160 mm. Larvae, called ammocoetes, and adults are found only in fresh water. Watercourses where it occurs are generally streams and rivers with gravel or sandy bottoms. The Northern Brook Lamprey requires two types of habitats during its life cycle, one for spawning adults and one, along the same watercourse, for the developing ammocoete. Habitat degradation and water pollution are the major threats to the survival of lampreys. The low fecundity and low dispersal abilities of the Northern Brook Lamprey make this species poorly adapted to withstand changes in its environment.

Key Words: Northern Brook Lamprey, *Ichthyomyzon fossor*, Petromyzontidae, status report, Québec.

Le genre *Ichthyomyzon* comprend six espèces qui se regroupent en trois paires, chacune étant composée d'une espèce parasite (espèce souche) et d'une espèce non parasite (espèce satellite; Vladykov et Kott 1979a). La Lamproie du Nord (*Ichthyomyzon fossor*), une espèce non parasite, serait issue de la Lamproie argentée (*Ichthyomyzon unicuspis*), une espèce parasite (Vladykov et Kott 1979a). Toutefois, certaines analyses génétiques récentes ont remis en question le fait que la Lamproie du Nord soit vraiment distincte de la Lamproie argentée (COSEPAC 2007*). La Lamproie du Nord est un petit poisson d'eau douce. Au stade larvaire, les larves, que l'on désigne sous le terme d'ammocètes, vivent enfouies dans les sédiments et se nourrissent par filtration. Au stade adulte, une fois la métamorphose terminée, l'espèce ne conserve pas de tractus intestinal fonctionnel et ne peut ainsi se nourrir. Au cours de sa vie, elle se reproduit seulement une fois et meurt peu de temps après la fraie.

L'aire de répartition de la Lamproie du Nord est limitée à l'Amérique du Nord. Au Canada, on la retrouve au Manitoba, en Ontario et au Québec. Elle a été identifiée au Québec comme espèce susceptible d'être désignée « menacée ou vulnérable ». Au Canada, la Lamproie du Nord n'est pas encore officiellement désignée, mais elle possède le statut d'espèce « préoccupante » attribué par le Comité sur la situation des espèces en péril au Canada (COSEPAC). Un rapport de situation, commandé par cet organisme, a été réalisé en 1991 (Lanteigne 1991*) et une mise à jour a été effectuée en 2007 (COSEPAC 2007*). Le présent article constitue une mise à jour du rapport de situation officiel soumis au ministère des Ressources naturelles et de la Faune du Québec (Fortin et al. 2005*).

Description

La taxinomie des lamproies holarctiques au stade adulte se fonde principalement sur quatre caractères, soit la disposition des dents, le nombre de myomères du tronc, les proportions du corps et la répartition géographique de l'espèce (Vladykov et Kott 1979b*). La longueur totale de la Lamproie du Nord adulte ne dépasse habituellement pas 160 mm (94 à 146 mm;

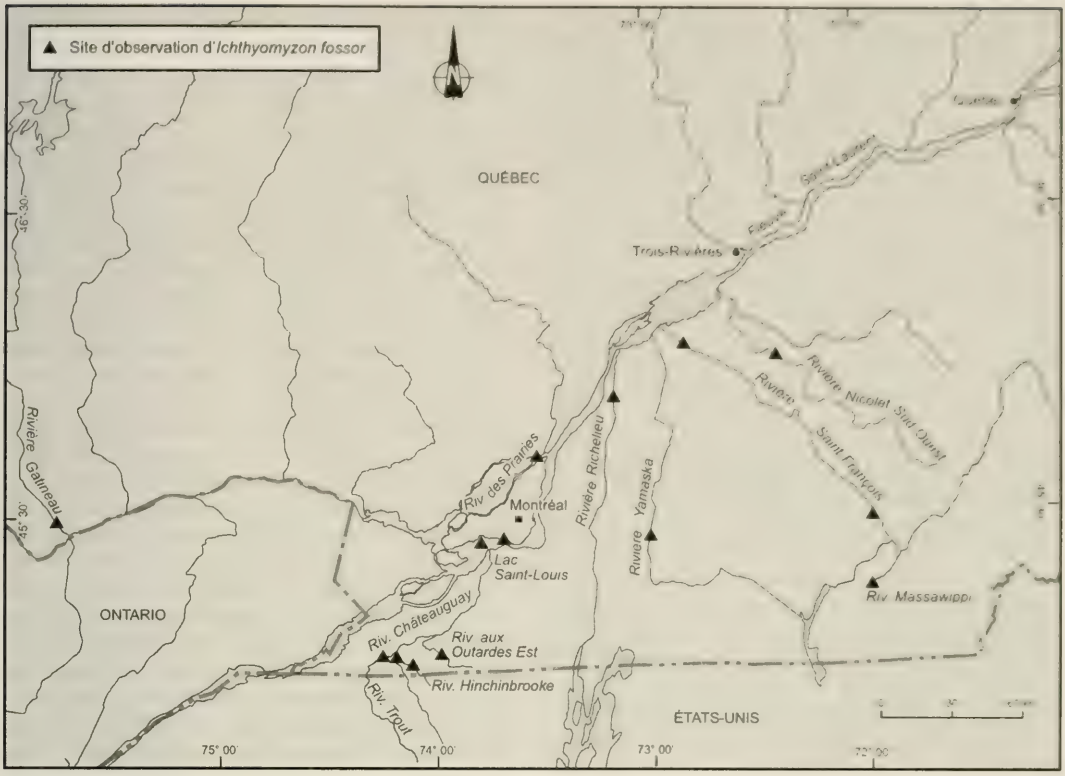

FIGURE 1. Répartition québécoise de la Lamproie du Nord, *Ichthyomyzon fossor*.

Hubbs et Trautman 1937; 128 à 150 mm: Vladykov 1952; 86 à 166 mm: Morman 1979*; 98 à 158 mm: Lanteigne 1981; 130 à 173 mm: Trautman 1981). Son corps est de forme cylindrique et sa tête est courte et dépourvue de mâchoire. Elle possède une bouche ronde en forme de ventouse dont l'ouverture est toujours plus courte que la longueur de la région branchiale. Elle est pourvue de sept paires de branchies. Les yeux sont petits et situés près du haut de la tête. Le nombre de myomères du tronc varie généralement entre 50 et 53 (Lanteigne 1988).

Les dents de l'entonnoir buccal sont peu développées. La lamina supraorale consiste en une dent pourvue de deux pointes alors que la lamina linguale transversale possède entre six et onze petites pointes sur l'arête denticulée (Scott et Crossman 1974). Les dents latérales internes consistent quant à elles en quatre dents unicuspides situées sur chaque côté du disque. Des dents latérales externes et de petites pointes situées dans les champs antérieur et postérieur complètent la dentition. La peau est lisse et ne possède pas d'écailles. L'adulte est bicolore : coloration gris foncé à brune sur le dos et les flancs et grise à blanc argenté sur les parties inférieures (Vladykov 1949*). La surface ventrale a une teinte orangée, particulièrement chez les femelles sexuellement matures (Leach 1940). Le repli anal est plus visible chez la femelle sexuellement mature que chez le mâle et est fusionné à la nageoire caudale (Scott et Crossman 1974). La nageoire dorsale est continue, ce qui la différencie de la Lamproie de l'Est (*Lampetra appendix*).

Répartition

La Lamproie du Nord est une espèce propre à l'Amérique du Nord. Au Canada, elle se retrouve dans le bassin hydrographique de la baie d'Hudson, au Manitoba, et dans le bassin hydrographique des Grands Lacs et du fleuve Saint-Laurent, en Ontario et au Québec (Lanteigne 1992). Aux États-Unis, elle se rencontre dans le bassin du Mississippi depuis le Wisconsin jusqu'à l'Ohio et vers le sud jusqu'au Kentucky (Lanteigne 1992). Il existe aussi une population disjointe au Missouri.

La connaissance de la répartition de la Lamproie du Nord au Québec est très restreinte. Elle se limite à des mentions rapportées dans le cadre de travaux de recherches et d'inventaires multispécifiques. Cette espèce n'a jamais fait l'objet d'un programme d'inventaire systématique et ciblé au Québec, à l'exception des travaux de Vladykov (1952) dans les années 1940 et 1950. Le manque de données sur sa répartition réside, entre autres, dans la nature discrète de ses mœurs tant au stade larvaire qu'adulte, à une faible longévité des individus une fois métamorphosés, à

leur petite taille, à la difficulté d'identifier les lamproies à l'espèce et dans le manque d'inventaires spécifiques. Les populations actuellement connues sont localisées dans le Québec méridional (Figure 1). Elles se retrouvent uniquement en eau douce dans le fleuve Saint-Laurent et dans le cours de certaines rivières tributaires du Saint-Laurent (Tableau 1). Des inventaires ciblés pourraient permettre de confirmer la présence de l'espèce ailleurs dans le fleuve Saint-Laurent et dans certains autres de ses tributaires.

La Lamproie du Nord a déjà été observée en grand nombre dans la rivière Yamaska (près de Saint-Césaire) entre 1946 et 1950 (Vladykov 1952). Malgré un effort intensif au moyen de la pêche électrique, aucun spécimen d'ammocète n'a été observé lors de travaux réalisés en 1990 (Renaud et al. 1995a) et 1992 (C. B. Renaud, non publié) à cette localité. Des quatre stations où Vladykov (1952) a trouvé des spécimens, le site de Saint-Césaire était qualifié d'endroit par excellence pour la Lamproie du Nord. L'espèce pourrait s'être maintenue dans la rivière Saint-François, près de Pierreville, où elle fut observée en 1947, 1951 et 1990. Vladykov (1952) qualifie ce site d'habitat idéal pour les ammocètes, en raison de l'abondance des îles et du substrat de fond favorable. La Lamproie du Nord a de nouveau été observée dans cette rivière en 2003, mais cette fois dans la localité de Bromptonville, à environ 130 km en amont de Pierreville (Desroches et al. 2008).

Biologie générale

Cycle vital

Le cycle vital des lamproies comprend deux stades : le stade larvaire (ammocète) et le stade adulte. Tôt après l'éclosion, la jeune ammocète émerge du nid et migre passivement vers l'aval. Après avoir trouvé un habitat favorable, elle creuse un trou en forme de U dans un substrat plutôt mou où elle demeure généralement cachée. Les ammocètes sont en effet des animaux fouisseurs relativement sédentaires (Potter 1980). Ce stade larvaire persiste de trois à six ans chez la Lamproie du Nord (Hardisty et Potter 1971a). Une fois qu'elle a atteint une certaine taille (moyenne de 131 mm: Leach 1940; moyenne de 114 mm: Purvis 1970), la larve se métamorphose entre les mois d'août et novembre. Le début de la métamorphose est synchrone entre les individus d'une même population; un accroissement rapide et substantiel de la température serait un des facteurs impliqués dans l'initiation de ce phénomène (Potter 1980). D'une durée de 2 à 3 mois, la métamorphose est un lent processus au cours duquel l'individu cesse de se nourrir (Leach 1940). On observe même une réduction de la longueur totale des individus au cours de cette phase. La bouche se transforme en un entonnoir buccal pourvu de dents. Cette période est suivie d'un stade adulte immature qui se déroule généralement entre novembre et février et au cours duquel l'individu est semi-sédentaire (Leach 1940). Une période plus active menant à la maturité sexuelle a lieu de février à mai. L'adulte ne se nourrit jamais. La fraie survient généralement en mai et est suivie quelques jours plus tard par la mort des individus reproducteurs.

Alimentation

Le régime alimentaire des ammocètes se compose principalement de détritus organiques, auxquelles s'ajoutent des algues unicellulaires (principalement des diatomées) et des bactéries (Sutton et Bowen 1994). Les ammocètes utilisent efficacement les détritus organiques pendant les mois les plus chauds lorsque la température des cours d'eau et la qualité des aliments sont plus favorables à l'alimentation, la digestion et la croissance (Sutton et Bowen 1994). Elles se nourrissent très lentement, ce qui leur permettrait d'utiliser au maximum une ressource de faible qualité. Leur taux d'alimentation est d'ailleurs consistant avec le faible métabolisme observé chez ce groupe de poissons (Hill et Potter 1970). Le taux d'alimentation dépend de la température et, à un degré moindre, de la densité des aliments (Moore et Mallatt 1980). La variation dans l'abondance des algues et des bactéries dans l'alimentation des ammocètes correspond à leur disponibilité dans les cours d'eau durant le cycle annuel (Sutton et Bowen 1994). Les bactéries et les algues ne peuvent cependant supporter à elles seules la croissance et le métabolisme des larves; les détritus organiques sont nécessaires à ces fonctions (Moore et Mallatt 1980; Sutton et Bowen 1994). La Lamproie du Nord adulte, tout comme les autres espèces de lamproies non parasites, ne conserve pas de tractus intestinal fonctionnel une fois la métamorphose complétée. Par conséquent, elle ne peut pas manger et n'atteint jamais la taille de l'espèce parasite à laquelle elle est apparentée, soit la Lamproie argentée (Vladykov et Kott 1979b*).

Reproduction

La Lamproie du Nord fraie uniquement en eau douce et atteint généralement l'âge de reproduction à six ans. Les lamproies ne pondent qu'une seule fois dans leur vie et tous les adultes meurent quelques jours après la fraie (Leach 1940). La température de l'eau est le facteur critique qui détermine le début de la période de reproduction chez les lamproies (Hardisty et Potter 1971b; Manion et Hanson 1980). Au Québec, la reproduction a lieu en mai, avec un pic de fraie à des températures de l'eau entre 13 et 16°C (Vladykov 1949*). Comtois et al. (2004) ont capturé une femelle en fraie un 23 juin dans la rivière Gatineau à une température de 19°C. Au Michigan, le pic de reproduction s'étend de la fin mai à la mi-juin, à une température de l'eau moyenne de 18°C (Morman 1979*). Toujours au Michigan, Reighard et Cummins (1916) rapportent une température optimale de l'eau entre 20 et 22°C ; la fraie était rarement observée à des températures inférieures à 18°C. Elle aurait lieu vers la fin mai dans la rivière Tippecanoe, en Indiana (Leach 1940).

TABLEAU 1. Liste des mentions d'observations de la Lamproie du Nord, *Ichthyomyzon fossor*, au Québec.

Cours d'eau	Localité	Année d'observation	Source
Fleuve Saint-Laurent	Rapides de Lachine	1950	Vladykov 1952
Lac Saint-Louis	Pointe-Claire	1941	CDPNQ[a]
Rivière Châteauguay	Athelstan	1990, 1992	Renaud et al. 1995b, 1998
Rivière des Prairies	Lachenaie	1998	CDPNQ
Rivière Gatineau	Gatineau	1999	Comtois et al. 2004
Rivière Hinchinbrooke	Hinchinbrooke	1976	MRNF[b]
Rivière Massawippi	North Hatley	1995	Desroches et al. 2008
Rivière Nicolet Sud-Ouest	Mitchell Station	1951	Vladykov 1952
Rivière aux Outardes Est	Franklin	2002	J. Dubé, communication personnelle
Rivière Richelieu	Saint-Roch-de-Richelieu	1990	Renaud et al. 1995b
Rivière Saint-François	Pierreville	1947, 1951	Vladykov 1952
	Pierreville	1990	Renaud et al. 1995a
	Bromptonville	2003	Desroches et al. 2008
Rivière Trout	Huntingdon	1976	CDPNQ
Rivière Yamaska	Saint-Césaire	1946 – 1950	Vladykov 1952
		1959	CDPNQ

[a] Centre de données sur le patrimoine naturel du Québec.
[b] Ministère des Ressources naturelles et de la Faune du Québec. Direction régionale de la Montérégie. Fichier informatisé des relevés fauniques en milieu aquatique et riparien.

En plus de la température de l'eau, deux autres facteurs sont essentiels au succès de ponte, soit un substrat adéquat et un courant uniforme et unidirectionnel s'écoulant au-dessus du nid (Manion et Hanson 1980; Lanteigne 1992). La Lamproie du Nord fraie dans des ruisseaux et des petites rivières sur fond de gros gravier, de galets (25 à 152 mm de diamètre) et de sable (Reighard et Cummins 1916; Scott et Crossman 1974). Bien que la fraie des lamproies soit généralement associée à des habitats peu profonds sans couvert de protection, il est maintenant admis que les espèces du genre *Ichthyomyzon* se reproduisent aussi sous un couvert de grosses roches ou de débris ligneux (Cochran et Gripentrog 1992). Ce comportement permettrait aux lamproies de se reproduire dans des milieux où l'eau est plus profonde et où le courant serait autrement trop fort pour frayer dans des milieux ouverts. Il réduirait aussi la vulnérabilité des reproducteurs à certains types de prédateurs (Cochran et Gripentrog 1992). Hardisty et Potter (1971b) rapportent que les cours d'eau typiques des lamproies de ruisseaux ont une vitesse du courant située entre 0,3 et 0,5 m/s dans les aires de fraie.

Les adultes ne semblent pas migrer en masse vers les aires de fraie (Leach 1940). Une fois arrivés sur les lieux, les reproducteurs se regroupent habituellement dans une aire restreinte (Scott et Crossman 1974). Les mâles amorcent alors la nidification (Manion et Hanson 1980; Moyle et Cech 2004). Ils établissent leurs nids en déplaçant de petits cailloux à l'aide de leur bouche afin de créer une légère dépression. Ils déplacent ensuite le sable à l'aide de mouvements vigoureux du corps (Hardisty et Potter 1971b). Le nid a un diamètre d'environ 7 à 10 cm (Scott et Crossman 1974). La profondeur se situe généralement entre 20 et 46 cm, de la surface de l'eau jusqu'au fond du nid (Hardisty et Potter 1971b; Scott et Crossman 1974). Leach (1940) rapporte qu'une femelle pond environ 1 195 œufs, mais cette donnée n'est basée que sur un échantillon composé de deux femelles. Pour sa part, Vladykov (1951) mentionne une moyenne de 1524 œufs (1115 à 1979), à partir de neuf spécimens récoltés au Québec. Le diamètre moyen d'un œuf se situe entre 1,0 et 1,2 mm (Vladykov 1951; Scott et Crossman 1974). Après la fertilisation, les œufs sont recouverts du substrat environnant le nid (Hardisty et Potter 1971b). Les oeufs éclosent 2 à 4 semaines plus tard (Leach 1940).

Déplacements

La répartition des lamproies le long d'un cours d'eau est le résultat de deux types de comportements liés aux déplacements des adultes et des larves. Le premier correspond à la migration vers l'amont des adultes reproducteurs aux aires de fraie. La migration des lamproies non parasites se ferait sur des distances beaucoup plus courtes que chez les espèces parasites (Hardisty et Potter 1971b). Le deuxième type de déplacements concerne la migration des ammocètes vers l'aval, là où les conditions d'envasement et de courant sont plus favorables à l'alimentation et à l'enfouissement dans le substrat. Cette migration est en partie passive (Potter 1980). Le déplacement des ammocètes est fonction de leurs mouvements, des conditions hydrographiques et hydrologiques locales, de la température de l'eau, de la saison, de la stabilité et de la nature du fond du cours d'eau, de la qualité de l'eau et de leur densité en relation avec la qualité de l'habitat (Hardisty et Potter 1971a; Morman et al. 1980; Potter 1980). Certains auteurs suggèrent que cette migration est minimale, tout particulièrement dans les cours d'eau où les gradients sont faibles, où l'écoulement est stable et où les habitats sont propices

(Morman et al. 1980). Elle pourrait cependant être plus importante dans les cours d'eau où les gradients sont plus importants, les ammocètes plus âgées étant de plus en plus prédominantes vers l'aval (Hardisty et Potter 1971a; Potter 1980). Bien que les ammocètes nagent relativement bien, il est improbable qu'elles puissent soutenir cette grande vitesse au cours d'une longue période (Potter 1980). Elles peuvent cependant nager à contre-courant, si ce dernier est faible (Hardisty et Potter 1971a). Les déplacements volontaires des ammocètes s'effectueraient principalement la nuit (Potter 1980), ce qui réduirait l'impact des prédateurs diurnes. La migration vers l'aval des individus métamorphosés se réalise aussi généralement la nuit et est influencée par le débit et la température du cours d'eau (Potter 1980).

Parasites et maladies

À notre connaissance, aucune étude n'a décrit la nature et la fréquence des parasites et des maladies spécifiques à la Lamproie du Nord. L'espèce est probablement susceptible à un bon nombre de maladies non spécifiques que l'on retrouve chez les autres poissons d'eau douce du Québec (Uhland et al. 2000). Chez la Lamproie marine (*Petromyzon marinus*), Wilson et Ronald (1967) ont observé que les adultes capturés en lac avaient un taux d'infection parasitaire (19 %) beaucoup plus faible que les spécimens qui retournaient en rivière pour frayer (53 %).

Longévité

Chez les lamproies, la durée du stade adulte est beaucoup plus courte que celle du stade larvaire. Dans le cas de la Lamproie du Nord, les adultes ne vivent qu'environ 6 mois, tandis que les ammocètes ont besoin de 3 à 6 ans pour arriver à leur métamorphose, selon le lieu et la nourriture (Okkelberg 1922; Leach 1940; Purvis 1970). L'âge maximum d'un adulte serait donc d'au plus 7 à 8 ans. La durée précise du stade larvaire est difficile à déterminer avec assurance car l'estimation est basée sur des classes de fréquence de longueur totale des individus (Leach 1940; Scott et Crossman 1974; Potter 1980).

Habitats

La Lamproie du Nord habite généralement les ruisseaux et les rivières à fond graveleux ou sablonneux (Jyrkkanen et Wright 1979; Morman 1979*). Au Québec, on la retrouve aussi dans le fleuve Saint-Laurent. Elle semble éviter les eaux stagnantes et les lacs (Hubbs et Trautman 1937). Dans le bassin hydrographique du lac Supérieur, Schuldt et Goold (1980) ont observé la Lamproie du Nord dans des cours d'eau de taille intermédiaire où le débit moyen estival variait de 0,3 à 28,3 m^3/s; l'espèce était commune dans plusieurs cours d'eau aux eaux turbides et habitait les régions de la tête des eaux. On ne retrouve la Lamproie du Nord qu'en eau douce; elle ne tolère aucunement la salinité (Vladykov 1949*). La rivière Yamaska, près de Saint-Césaire, représentait un habitat typique de la Lamproie du Nord selon Vladykov (1952).

En fonction de l'âge des individus, la Lamproie du Nord requiert deux habitats distincts le long d'un cours d'eau donné, soit un pour les adultes reproducteurs et un autre pour le développement des ammocètes. Les adultes reproducteurs ont besoin de petits cours d'eau aux eaux claires et à gradient topographique élevé, avec présence de rapides et un fond de gravier et de sable (Trautman 1981). Quant aux ammocètes, elles préfèrent la portion des cours d'eau à courant plus lent, là où le substrat est propice à l'enfouissement (substrat mou; Potter et al. 1986). Ce substrat renferme souvent un contenu élevé en matériel organique (Hardisty et Potter 1971a; Potter et al. 1986; Beamish et Lowartz 1996). La composition des sédiments, dont la taille des particules ainsi que l'hétérogénéité, constitue un facteur important dans la sélection de l'habitat (Hardisty et Potter 1971a; Anderson et White 1988; Beamish et Lowartz 1996). Les ammocètes éviteraient les fonds composés principalement de très petites ou de grosses particules, le fond étant trop compact dans le premier cas et les particules trop lourdes pour être délogées par les larves dans le second (Beamish et Lowartz 1996). La taille idéale correspondrait à du sable mi-fin.

Au Michigan, Morman (1979*) a observé que la Lamproie du Nord était plus tolérante à l'eau chaude que les autres espèces étudiées. Les plus grandes densités d'ammocètes se retrouvaient habituellement dans les sections les plus chaudes des cours d'eau. Ce type de milieux serait généralement non propice à la présence de l'Omble de fontaine (*Salvelinus fontinalis*; Vladykov 1949*). Les ammocètes sont photophobiques, ce qui expliquerait pourquoi l'ombre est un facteur qui influence significativement leur répartition (Potter et al. 1986). La quantité de chlorophylle *a* à la surface du substrat serait aussi une variable environnementale importante expliquant la densité des larves de lamproie (Potter et al. 1986). Cette observation reflète bien l'importance des diatomées et autres microalgues dans le régime alimentaire des ammocètes qui évitent généralement les eaux stagnantes ou trop riches en matière organique, là où la teneur en oxygène est faible (Potter 1980).

Dynamique des populations

Les connaissances sur la dynamique des populations de la Lamproie du Nord sont limitées. La fécondité de cette espèce fut caractérisée au Québec par Vladykov (1951) et est considérée faible par rapport aux autres espèces de lamproies étudiées. La survie des œufs dans les nids n'a pas été déterminée chez la Lamproie du Nord, mais chez la Lamproie marine, celle-ci est élevée, pouvant atteindre 90 % (Manion et Hanson 1980). À partir d'un échantillon de 627 larves de Lamproie du Nord, Purvis (1970) a observé un rapport des sexes de 1 : 1 dans un tributaire du lac Supérieur, au Michigan. Chez les adultes reproduc-

teurs, il semble que le rapport des sexes favorise les mâles (75 %, Purvis 1970; 71 %, Jyrkkanen et Wright 1979). Ce phénomène est observé chez plusieurs autres espèces de lamproies non parasites (Potter 1980).

Chez la Lamproie du Nord, comme chez d'autres espèces de lamproies, une classe d'âge peut contribuer à plusieurs cohortes de reproducteurs. En effet, seule une fraction d'une classe d'âge se métamorphose une année donnée, les autres individus de la même classe se métamorphosant au cours des années suivantes (Purvis 1970). Ce recrutement de différentes classes d'âge à la population reproductrice pourrait expliquer les fluctuations de populations observées chez la Lamproie de Planer (*Lampetra planeri*), une espèce européenne (Hardisty 1961). La température de l'eau et la disponibilité de nourriture seraient des facteurs déterminants pour la croissance des ammocètes (Hardisty et Potter 1971a). La croissance variait beaucoup entre les classes d'âge étudiées par Purvis (1970). L'auteur suggère que cette différence est principalement causée par une forte diminution de la densité de la population consécutive à des traitements chimiques avec des lampricides. Il en résulterait une diminution de la compétition pour la nourriture et l'espace et une augmentation de la croissance dans la population résiduelle.

Pressions sur l'espèce, facteurs limitants et adaptabilité

La détérioration de l'habitat constitue probablement la principale pression sur l'espèce (Vladykov 1973; Renaud 1997). Différents types de pollution, seule ou en combinaison avec d'autres facteurs, restreignent la répartition des lamproies (Morman et al. 1980; Renaud 1997). La pollution de l'eau liée au développement agricole semble être la principale cause de la disparition apparente de la Lamproie du Nord de la rivière Yamaska, au niveau de Saint-Césaire (Renaud et al. 1995a). Les programmes de contrôle chimique de la Lamproie marine introduite dans les bassins hydrographiques des lacs Huron, Michigan et Supérieur (Smith et Tibbles 1980) ont affecté les populations locales d'autres espèces de lamproies, dont la Lamproie du Nord (Schuldt et Goold 1980). Les larves de cette espèce ainsi que de la Lamproie argentée ont disparu de 41 des 81 cours d'eau traités du bassin hydrographique du lac Supérieur qu'elles fréquentaient jadis, tant au Canada qu'aux États-Unis (Schuldt et Goold 1980). Le lampricide utilisé, le 3-trifluorométhyl-4-nitrophénol (TFM), est destiné à tuer les larves avant leur métamorphose. Le genre *Ichthyomyzon* serait de susceptibilité intermédiaire au TFM (Davis 1970).

La Lamproie du Nord était utilisée autrefois comme appât pour la pêche sportive (Vladykov 1973). Vladykov (1952) mentionne des récoltes totales annuelles d'environ 300 000 ammocètes pour l'ensemble du Québec dans les années 1940 et 1950, toutes espèces confondues. L'impact qu'a eu cette pratique sur les populations québécoises est cependant inconnu. Cette utilisation pour la pêche sportive est maintenant interdite au Québec. L'accumulation de sédiments transportés par l'eau jusqu'aux aires de fraie, les barrages et autres obstacles bloquant les remontées d'adultes reproducteurs et l'abaissement du niveau de l'eau, lesquels constituent une menace pour la survie des larves dans leurs abris, représentent d'autres pressions sur l'espèce (Scott et Crossman 1974; Morman et al. 1980; Lanteigne 1992; Renaud 1997).

La mortalité peut parfois être élevée au tout début du cycle vital (Potter 1980). Diverses espèces de poissons ont en effet été observées en train de se nourrir d'œufs de lamproies ou de très jeunes larves (Hardisty et Potter 1971a; Vladykov 1973; Potter 1980; Lanteigne 1992). Les jeunes larves sont aussi susceptibles à la prédation lorsqu'elles quittent le nid et migrent vers l'aval (Hardisty et Potter 1971a; Potter 1980). La prédation sur les ammocètes plus âgées ne semble cependant pas être un facteur de mortalité important car elles demeurent enfouies (Potter 1980). Trautman (1981) considère les ammocètes et les adultes comme très vulnérables à la prédation par d'autres poissons. Par ailleurs, des cas de prédation sur les adultes reproducteurs ont été rapportés pour une panoplie de prédateurs tels que belette, chien domestique, couleuvre d'eau, goéland, héron, rat musqué, raton laveur et renard (Morman et al. 1980). Les lamproies au nid sont davantage susceptibles à la prédation, car elles sont plus exposées dans des eaux relativement peu profondes.

La compétition interspécifique, les parasites et les maladies ne semblent pas influencer de façon importante la répartition et l'abondance de la Lamproie marine (Morman et al. 1980). L'importance de ces derniers facteurs pour la Lamproie du Nord reste inconnue. La faible fécondité de la Lamproie du Nord suggère qu'il pourrait être plus difficile pour elle de se rétablir à la suite d'un déclin des populations (Schuldt et Goold 1980; Lanteigne 1992). Aussi, la mobilité restreinte de l'espèce limite ses chances de pouvoir recoloniser les cours d'eau où elle aurait disparu. Ces éléments font de la Lamproie du Nord une espèce peu adaptable aux modifications de son environnement.

Importance particulière de l'espèce

Même si les lamproies constituent un mets de choix dans certaines régions hors Québec (Moyle et Cech 2004), ce type de poissons est actuellement sans grande valeur économique. N'étant pas un poisson parasite, la Lamproie du Nord ne présente pas le danger de blesser ou de tuer d'autres espèces de poissons, au contraire de la Lamproie marine par exemple. La Lamproie du Nord présente cependant un intérêt certain d'ordre scientifique et écologique. Cette espèce fait en effet partie d'un groupe de poissons parmi les plus primitifs (Forey et Janvier 1993) et offre ainsi l'occasion d'étudier l'évolution des poissons et les raisons pour lesquelles les lamproies ont continué à se maintenir dans un environnement en perpétuel change-

ment (Lanteigne 1992; Moyle et Cech 2004). Les lamproies sont également utiles comme animaux de laboratoire, particulièrement en neurobiologie (Moyle et Cech 2004). Les ammocètes filtrent différents types de micro-organismes et constituent une source de nourriture pour plusieurs espèces de poissons, d'où leur importance dans la chaîne alimentaire (Vladykov 1973). La présence de ce poisson dans le Québec méridional contribue aussi à la biodiversité des ruisseaux et des rivières. Comme les ammocètes sont des poissons relativement sédentaires passant une bonne partie de leur vie enfouis dans les sédiments, elles représentent ainsi des bio-indicateurs potentiels des niveaux de contaminants persistants dans les milieux d'eau douce. Une étude réalisée au Québec a démontré que les ammocètes, et notamment celles de la Lamproie du Nord, sont aussi appropriées que les mollusques bivalves adultes comme baromètres des niveaux de contaminants organochlorés (Renaud et al. 1995b). Elles sont considérées comme un bon bio-indicateur de la contamination au mercure en plus de pouvoir indiquer les différences dans les niveaux de contamination en métaux entre les rivières (Renaud et al. 1998).

Bilan de la situation

Taille des populations et tendances démographiques

Aucune estimation de la taille totale des populations de la Lamproie du Nord n'est disponible pour le Québec ou ailleurs dans son aire de répartition (COSEPAC 2007*). On ne connaît donc pas sa situation exacte ni la tendance démographique des populations identifiées à ce jour. Seules des données ponctuelles de taille de populations sont disponibles, lesquelles sont présentées ci-après.

À Saint-Césaire, dans la rivière Yamaska, 61 adultes et 842 ammocètes ont été capturés entre 1946 et 1950, dont 721 ammocètes entre le 27 juillet et le 30 août 1949, au cours d'une étude menée par Vladykov (1952). En dépit d'un effort de pêche intensif, aucun spécimen n'a été capturé au même endroit en 1990 et 1992 (Renaud et al. 1995a; C. B. Renaud, non publié). L'état actuel de l'espèce dans l'ensemble de la rivière reste à préciser.

Deux individus métamorphosés et plusieurs ammocètes ont été recensés dans la rivière Saint-François près de Pierreville entre 1947 et 1951 (Vladykov 1952). Une étude réalisée en 1990 a permis la récolte de deux ammocètes dans cette localité, près de l'île Cartier (Renaud et al. 1995a). L'espèce était donc toujours présente à l'époque, bien qu'aucune donnée ne soit disponible quant à l'abondance de la population. La situation actuelle à cette localité demeure inconnue. Toutefois, l'espèce fut de nouveau observée dans cette rivière le 26 août 2003 à Bromptonville, soit à 130 km en amont de la localité de Pierreville (Desroches et al. 2008). Il s'agissait d'une ammocète vivante trouvée dans un bassin. De même, environ douze ammocètes mortes et deux vivantes ont été observées le 20 septembre 1995 dans la rivière Massawippi, un tributaire de la rivière Saint-François, à North Hatley (Desroches et al. 2008). Quelques secteurs du bassin versant de la rivière Saint-François semblent donc propices à la Lamproie du Nord.

Une seule femelle adulte a été capturée dans la rivière Gatineau en 1999 (Comtois et al. 2004). Un seul individu a aussi été capturé dans la rivière aux Outardes Est en 2002 (Jean Dubé, communication personnelle). La mention de la localité des Rapides de Lachine concerne six ammocètes capturées le 26 juillet 1950 alors que celle du bassin de la rivière Nicolet (rivière Nicolet Sud-Ouest) se rapporte à une ammocète notée le 22 juillet 1951 (Vladykov 1952). Respectivement trois et six individus de sexe et de stade indéterminé ont été rapportés sur les rivières Trout et Hinchinbrooke en 1976 par le Centre de données sur le patrimoine naturel du Québec (CDPNQ) et le ministère des Ressources naturelles et de la Faune du Québec, ainsi qu'un adulte en 1998 dans la rivière des Prairies par le CDPNQ. Finalement, la mention de 1990 de la rivière Richelieu concerne cinq ammocètes (Renaud et al. 1995b).

Menaces à la survie de l'espèce au Québec

La détérioration de l'habitat et la pollution des eaux semblent représenter les principales menaces à la survie des lamproies (Renaud 1997; Moyle et Cech 2004), incluant la Lamproie du Nord. La pollution de la rivière Yamaska, associée à une agriculture intensive et à des rejets industriels et urbains, apparaît comme une cause possible de l'absence de mention de l'espèce dans la localité de Saint-Césaire en 1990 et 1992 (Renaud et al. 1995a; C. B. Renaud, non publié). L'utilisation intensive de l'herbicide atrazine appliqué dans la culture du maïs serait également en cause. Lessivé dans la rivière suite aux fortes pluies, ce produit chimique réduirait de façon importante le phytoplancton dont se nourrissent les ammocètes (Renaud et al. 1995a). On retrouve également de nombreux autres pesticides dans la rivière Yamaska et plusieurs de ses tributaires, dont le métolachlore, la cyanazine et le dicamba (Gouvernement du Québec 1998*). Il n'est pas rare de découvrir plus de six pesticides différents au même endroit. La prédominance de la culture du maïs qui nécessite régulièrement l'application de ces produits expliquerait en bonne partie cette situation. Malgré tous les efforts qui ont été déployés au cours des dernières années, la rivière Yamaska présente toujours la pire qualité d'eau au Québec. Le portrait n'est pas plus réjouissant dans le secteur particulier de Saint-Césaire (Gouvernement du Québec 1998*).

D'autres rivières où l'espèce fut observée telles que les rivières Richelieu et Nicolet, sont aussi d'une qualité relativement mauvaise (Gouvernement du Québec 1993*, 1995*). En fait, depuis 1992, le ministère du Développement durable, de l'Environnement et des Parcs mène un programme de suivi annuel des

pesticides dans quatre cours d'eau des régions agricoles où la culture du maïs est importante (Gouvernement du Québec, 2006*). Ces sont les rivières Chibouet (bassin de la rivière Yamaska), des Hurons (bassin de la rivière Richelieu), Saint-Régis (affluent direct du fleuve Saint-Laurent) et Saint-Zéphirin (bassin de la rivière Nicolet). Des pesticides ont régulièrement été détectés durant l'été dans ces rivières. Les substances trouvées le plus souvent sont l'atrazine, le métolachlore, le bentazone, le dicamba, le 2,4-D et le diméthénamide. Ces substances représentent autant de menaces pour la Lamproie du Nord en affectant la qualité de l'eau.

Une autre menace importante à la survie de la Lamproie du Nord au Québec est la disparition des bandes riveraines qui provoque l'érosion des sols et augmente la sédimentation dans les lits des cours d'eau, altérant ainsi les aires de fraie. Ce phénomène constitue une menace importante pour les lamproies (Moyle et Cech 2004). Les bandes riveraines boisées, par leur rôle de filtres et de stabilisateurs des berges, protègent aussi les cours d'eau contre les apports en fertilisants et en pesticides (Société de la faune et des parcs du Québec 2003*). Elles procurent aussi de l'ombre, élément important de l'habitat des ammocètes (Potter et al. 1986). Les superficies requises pour épandre les surplus de lisier de porc et les monocultures comme celle du maïs sont, entre autres, responsables de la disparition des bandes riveraines (Société de la faune et des parcs du Québec 2003*). Les régions de la Montérégie, du Centre-du-Québec et de Chaudière-Appalaches sont particulièrement touchées à cet égard.

La croissance de l'industrie porcine a provoqué une surcharge de fumier et de ses substances polluantes. L'excès de fertilisant, et tout particulièrement le phosphore, touche directement la qualité de l'habitat de la Lamproie du Nord via l'eutrophisation des cours d'eau (Société de la faune et des parcs du Québec 2003*). Cette menace touche potentiellement les cours d'eau de la Montérégie, du Centre-du-Québec et de Chaudière-Appalaches, lesquelles ont été particulièrement touchées par la production porcine au cours des dernières décennies, comme par exemple les rivières Nicolet, Richelieu, Saint-François et Yamaska.

D'autres menaces potentielles pour l'habitat de la Lamproie du Nord concernent le redressement des petits cours d'eau, lequel pourrait endommager l'habitat utilisé par les adultes reproducteurs, ainsi que la présence d'obstacles (ex. barrages) à la libre circulation de l'espèce entre ses habitats de reproduction et de développement des ammocètes.

Statut actuel et protection légale

La Lamproie du Nord a été identifiée au Québec comme espèce susceptible d'être désignée « menacée ou vulnérable » en vertu de la *Loi sur les espèces menacées ou vulnérables*. Au Canada, la Lamproie du Nord figure à l'annexe 3 de la *Loi sur les espèces en péril* à titre d'espèce « préoccupante », désignation donnée par le COSEPAC en 1991 et une mise à jour a été effectuée en 2007 (COSEPAC 2007*). En tant qu'espèce de poissons, la Lamproie du Nord est protégée au Québec en vertu de la *Loi sur la conservation et la mise en valeur de la faune*. L'habitat de l'espèce n'est protégé au Québec que sur les terres publiques par l'application du *Règlement sur les habitats fauniques*, de même qu'à l'échelle fédérale, tant sur les terres privées que sur les terres publiques, en vertu de la *Loi sur les pêches* et la *Politique de gestion de l'habitat du poisson*. Au Québec, la *Loi sur la qualité de l'environnement* et la *Politique de protection des rives, du littoral et des plaines inondables* s'appliquent également à l'habitat de l'espèce autant en terres publiques que privées.

Évaluation

Il existe un urgent besoin de réaliser des travaux d'inventaire spécifiques et d'effectuer un suivi des populations de Lamproie du Nord au Québec, en donnant priorité aux sites actuellement connus. Des vérifications s'imposent pour savoir si l'espèce a survécu dans ces cours d'eau et, le cas échéant, si ces populations et leurs habitats sont en bonne santé. Une estimation de la taille des populations serait aussi souhaitable. Cette initiative devrait être considérée comme prioritaire dans le contexte de la conservation de l'espèce au Québec. Actuellement, on estime que 55 % des espèces de lamproies de l'hémisphère nord sont en difficulté (Renaud 1997).

Nos connaissances actuelles sur la situation de la Lamproie du Nord au Québec vis-à-vis sa répartition et l'état de ses populations ne nous permettent pas de nous prononcer quant à la catégorie de conservation à attribuer à cette espèce. En effet, contrairement à sa situation dans la région des Grands Lacs où l'effort de pêche est connu à cause du programme de contrôle de la Lamproie marine, *Petromyzon marinus*, permettant ainsi de déterminer les tendances des populations de toutes les espèces de lamproies de cette région, les mentions de la Lamproie du Nord au Québec ne sont pas le résultat d'un suivi de longue durée mais plutôt la conséquence de travaux d'inventaire ichtyologique d'ordre généraux (e.g. Comtois et al. 2004). De plus, ce n'est que tout récemment (Desroches et al. 2008) que la présence de la Lamproie du Nord est connue bien en amont de la rivière Saint-François, à environ 130-165 km de la localité originale de Pierreville (Vladykov 1952), une indication de notre manque d'inventaire à l'échelle de la province. COSEPAC (2007*) attribua à la Lamproie du Nord de la région des Grands Lacs et du haut Saint-Laurent le statut d'espèce « préoccupante » en raison des menaces dues à l'épandage de larvicides sur environ 50% de son aire de répartition (i.e. la région des Grands Lacs). Nous souhaitons donc que notre article serve de point de référence pour des études de suivi sur la Lamproie du Nord au Québec et lançons un appel pour celles-ci.

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Seasonal Variation in Sex Ratios Provides Developmental Advantages in White-tailed Deer, *Odocoileus virginianus*

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Since Trivers and Willard first proposed their hypothesis concerning the adaptive advantages of producing a particular offspring sex in relation to maternal condition in 1973, it has been at the forefront of scientific research concerning sex ratios with most subsequent studies focusing on maternal condition as a key contributor to variations in sex ratios. Another factor that could greatly influence sex ratios, although has been only infrequently examined in mammalian species, is birth date. We investigated how birth date influenced offspring sex ratios in White-tailed Deer (*Odocoileus virginianus*). Since date of birth can greatly influence an individual's fitness and reproductive success, we suggest that birth date may be an alternative strategy in determining offspring sex ratios. Since it has been shown that the lifetime reproductive fitness of a mother can be increased by producing a particular sex during a particular time, we hypothesized that more male offspring should be born earlier in the season due to their increased reproductive potential from being born at this time. Offspring born earlier will have a head start in development and therefore have greater potential for increased body size and dominance later in life, traits that greatly influence male reproductive success. In this study, we found that maternal condition did not affect offspring sex ratio in a captive population of White-tailed Deer in Michigan; however, birth date did. We found that more males tended to be born during the second and fourth birthing periods, while more females were born during the first, third and fifth periods. In addition, we found that males born earlier in the season had greater mass the following spring than those born later, a trend that was not as dramatic in females. These results lend moderate support to our hypothesis that in White-tailed Deer offspring sex will tend to vary according to timing of birth and relative reproductive advantages gained by a particular sex being born at that time.

Key Words: White-tailed Deer, *Odocoileus virginianus*, birth date, early bird hypothesis, local resource competition, seasonality, secondary sex ratio, temporal variation, Trivers-Willard hypothesis.

The potential for offspring sex ratios to differ from parity has been well documented in a number of mammalian species, including White-tailed Deer (*Odocoileus virginianus*) (Verme and Ozoga 1981; Kojola and Eloranta 1989; Kucera 1991; Landete-Castillejos et al. 2001; Landete-Castillejos et al. 2004; Sheldon and West 2004). This strategy could enhance the lifetime fitness of a female by producing the sex with the greatest potential reproductive value. Some factors shown to influence this variation include: maternal age, condition, social status, and habitat quality. Trivers and Willard (1973) proposed that females of sexually dimorphic, polygynous species in good condition would benefit more from producing sons, because the mother's condition would more strongly influence the future reproductive success of sons than daughters. Conversely, females in poor condition would benefit most by producing daughters, since female offspring require less maternal investment (i.e., milk production) and will likely reproduce regardless of maternal condition. Poor quality male offspring likely will not develop the physical characteristics necessary to compete successfully for females later in life. Assumptions for the Trivers and Willard hypothesis include: condition of offspring is correlated with condition of the mother after the parental investment period, condition of the young following the parental investment period will carry over to adulthood, and conditional advantages will differentially benefit male offspring in reproductive success (Trivers and Willard 1973). Since most ungulate species are polygynous, sexually dimorphic species which commonly exhibit these three assumptions (Hewison and Gaillard 1999), numerous studies have been conducted to test the Trivers-Willard hypothesis. In several of these studies, support for the Trivers-Willard hypothesis has been documented, where older or more dominant individuals gave birth to more males, and younger or subordinate females gave birth to more females (Landete-Castillejos et al. 2001; Landete-Castillejos et al. 2004; Sheldon and West 2004).

Despite the many findings that support Trivers and Willard (Landete-Castillejos et al. 2001; Landete-Castillejos et al. 2004; Sheldon and West 2004), numerous studies have reported data that seem to contradict their hypothesis. In a review of published papers on

the genus *Odocoileus*, Verme (1983) found that more males were produced by younger females, females in poor condition, and females in areas of poor habitat quality. Similarly, Mendl et al. (1995) discovered that more female offspring were produced by dominant females in domestic pigs (*Sus scrofa*). These contradicting trends have been explained by alternative hypotheses for biased sex ratios, including: the local resource competition hypothesis (Clark 1978), the advantaged daughter hypothesis (Hiraiwa-Hasegawa 1993), and the advantaged matriline hypothesis (Leimar 1996). According to the advantaged daughter and the advantaged matriline hypotheses, mothers are better able to influence the reproductive success of daughters rather than sons (e.g., by the transfer of rank and/or access to high quality resources). Therefore, these hypotheses propose that high quality females are more likely to produce females than males. Conversely, the local resource competition hypothesis states that local resources rather than maternal condition drive biases in sex ratios. In matriarchal species, Clark (1978) proposed that females in good condition will produce more female offspring, whereas females in poor condition will invest more in male offspring. This is because female offspring normally establish home ranges that overlap their mother's home range, while males tend to disperse, creating less competition for resources in the future.

While they differ, all of these hypotheses focus on maternal condition as the driving factor in offspring sex ratios of mammals. Another factor that should greatly influence reproductive potential of offspring and offspring sex ratios is birth date. In many sexually dimorphic species, it is believed that time at birth differentially affects the ability of a particular sex to reproduce during its first and subsequent years (Suttie 1983; Clutton-Brock et al. 1984; Kruuk et al. 1999; Festa-Bianchet et al. 2000). Therefore, having biased sex ratios of offspring according to birth date could increase a female's lifetime fitness. A number of avian species have been shown to have varying sex ratios seasonally, including the Northern Goshawk (*Accipiter gentiles*: Byholm et al. 2002), European Kestrel (*Falco tinnunculus*: Pen et al. 1999), Common Sandpiper (*Actitis hypoleucos*: Andersson et al. 2003), American Kestrel (Smallwood and Smallwood 1998; *F. sparverius*: Griggio et al. 2002), Spotted Starling (*Sturnus unicolor*: Cordero et al. 2001), and Little Grassbirds (*Megalurus gramineus*: McIntosh et al. 2003). In their work with a nonmigratory population of American Kestrels, Smallwood and Smallwood (1998) found more male-biased sex ratios earlier in the season compared to later and proposed that males that fledged earlier could find nest sites and defend territories better than males that fledged later. Griggio et al. (2002) found the same results in a migratory population of American Kestrels, with more males born earlier in the season. Similarly, it was determined that the sex ratio variation could be due to acquisition of nest sites that were limited for this population. In contrast, competition for mates seemed the most likely explanation for male-biased sex ratios early in season in the Common Sandpiper, because males born earlier have an advantage in obtaining mates (Andersson et al. 2003). Although the explanations for these trends differ, they suggest that varying offspring sex ratios by birth date has an adaptive advantage to a mother by enhancing her own future fitness. Smallwood and Smallwood (1998) coined this trend the "Early Bird Hypothesis" and predicted that the sex which gains the greatest advantage by hatching earlier is selected for in early conception dates in avian species.

The Early Bird Hypothesis (Smallwood and Smallwood 1998), however, has not been evaluated in mammals. While it has been demonstrated that older individuals tend to give birth earlier (Johns et al. 1977; Festa-Bianchet 1988; Christley et al. 2002), older individuals tend to produce more male offspring (Landete-Castillejos et al. 2004), and offspring born earlier are more likely to survive due to increased food resources (Festa-Bianchet 1988; Singh et al. 1990; Festa-Bianchet et al. 1997; Côté and Festa-Bianchet 2001), the link to differential sex ratios based on birth date has not been well documented in mammalian species. We hypothesize that birth date is a driving factor in offspring sex ratios, with females producing more male offspring earlier in the breeding season and increasing production of females as the season progresses. Because offspring born earlier should have a longer period of time to grow before their first winter, more males should be produced at this time period because of the relative importance of size on future reproductive success in males and females.

Materials and Methods

We analyzed data from the Cusino enclosure, a 252-ha enclosure located near Shingleton, 46°21'N, 86°28'W, in Michigan's Upper Peninsula from 1973 through 1984 (excluding 1974). The enclosure consisted mainly of northern hardwoods, mixed hardwood-conifer stands, and pine (*Pinus sp.*) plantation. Due to initial overbrowsing and subsequent condition decline, deer were supplementally fed ad libitum year-round with a pelleted ration beginning in 1972 and were fed throughout the study period. Following this, deer were documented to be in good physical condition, even during winter months (Ozoga and Verme 1982). Initially (1972-1976), no deer were intentionally removed from the enclosure; however, to ensure a stable population, the number of individuals within the enclosure was maintained at approximately 40 individuals with the removal of most fawns and older individuals each year starting in 1977 (Ozoga and Verme 1982). Although some potential bias could result from the removal of such individuals, in a natural population, most mortality would occur among

the removed age classes (i.e., young and old individuals). Therefore, we assume the conditions within the enclosure are representative of a natural population, and in fact, the ages of mothers observed in this study (i.e., 1 to 13 years of age) falls within the natural range of breeding females (e.g., ages of pregnant deer darted in Alabama ranged from 1 to 13 year of age as determined by annuli in the cementum; S. T. Saalfeld, unpublished data).

A complete population census was obtained annually in March by live-trapping deer and placing them in a holding pen. At this time, all deer were marked with numbered collars and weighed. In addition, adult does were X-rayed to determine stage of pregnancy and number of fetuses (Ozoga and Verme 1982). Age of fetuses was determined by comparing fetal radiograms with known-age fetal specimens (105 specimens ranging from 76 to 137 days old) determined by observed breeding dates (Ozoga and Verme 1985). Following this, birth dates were ascertained by using a 199-day gestation. Accuracy of this procedure was assessed by comparing predicted dates with known birth dates for 90 litters, and was found to be accurate within 3 days in 50% of litters, within 5 days in 66% of litters, and within 9 days in 93% of litters (Ozoga and Verme 1985). This variability fell within the natural variation expected in gestation times of well-nourished females (i.e., 196-213 days; Ozoga and Verme 1985). Pregnancy in fawns was also monitored at this time. Since fetuses within fawns would be too small to be detected on radiograms due to late conception dates, the presence of pregnancy in fawns was monitored through progesterone assay in peripheral plasma (Plotka et al. 1977).

Following the above procedures, deer were released back into a holding pen where they could be observed to confirm mother-fawn lineage from the previous year in some instances. Although most fawns were captured and tagged whenever possible within the enclosure to identify their mother, some were not captured until the March census. Therefore, observations at this time were used to either confirm or determine mother-fawn lineage as well as to document the dominance hierarchy among the deer. The dominance number assigned to each individual corresponded to the percentage of the herd that the individual dominated while inside the holding pen. Dominance was determined by observing interactions at feeding stations and recording the number of individuals dominated by a particular individual. All deer were released from the holding pen in late March or early April, and thereafter, observations were used to further elucidate behavioral patterns, social habits, birthing periods, rearing success, and sex of offspring. Fawns were captured and tagged whenever the opportunity arose and therefore most were already identified prior to the following March census. Those that were not tagged by the March census were identified and tagged for visual identification at this time (Ozoga and Verme 1982). All research was performed in a humane manner, followed ASM guidelines, and was approved by an institutional animal care and use committee.

In order to determine any possible role of birth date on offspring sex ratio we analyzed data similar to Smallwood and Smallwood (1998). We subdivided fetuses into 10-day intervals for the range of birth dates determined from fetal radiograms in this study (13 May–25 July). Since not all groups had adequate sample sizes (Figure 1), we pooled data of groups with samples sizes less than 10 litters. This resulted in the pooling of dates after 22 June. We then tested whether sex ratios differed among these groups using repeated measures analysis of variance repeated among years with a compound symmetric covariance structure and birthing group nested within year as our error term (PROC MIXED: SAS Institute 1999). In addition, to determine differences in physical condition by birth date between sexes, we tested if mass of fawns measured the following spring (March) differed among birthing groups (e.g., birth date) within each sex using the same repeated measures analysis of variance. To test the validity of maternal-condition-based hypotheses within this population, we investigated if any difference existed among maternal condition (i.e., body mass and dominance) or age for females that produced male or female fawns using repeated measures analysis of variance repeated among years with a compound symmetric covariance structure. Although we were unable to account for repeatedly sampling females, we tested whether sex ratios among the different birthing periods differed from equality using a Pearson chi-square.

Results

A total of 428 fawns from 251 litters was examined during the study from fetal radiograms: mean birth date was 4 June (n = 230; SE = 0.63 days), and mean number of fawns per doe was 1.85 (n = 230; SE = 0.04). The offspring sex ratio (50.4%) for the entire study did not differ from equality (χ^2 = 0.02; P = 0.880). We detected a difference ($F_{4,58}$ = 2.86; P = 0.031; Figure 2) in the proportion of males born among time periods, with a greater tendency of males being born in the second and fourth periods. We detected a greater proportion of males being born between 12 June and 21 June (70.4%) than between 13 May and 22 May (38.9%; t_{58} = –2.30; P = 0.025), 2 June and 11 June (46.5%; t_{58} = –2.78; P = 0.007), and 22 June and 25 July (38.9%; t_{58} = 2.11; P = 0.040). We also found a tendency for more males being born between 23 May and 1 June (58.0%) than between 2 June and 11 June, however only approaching significance (t_{58} = 1.78; P = 0.081). We found no differences among other time periods (P > 0.050). Additionally, we found that the second birthing period had a sex ratio different than equality (χ^2 = 3.93; P = 0.047).

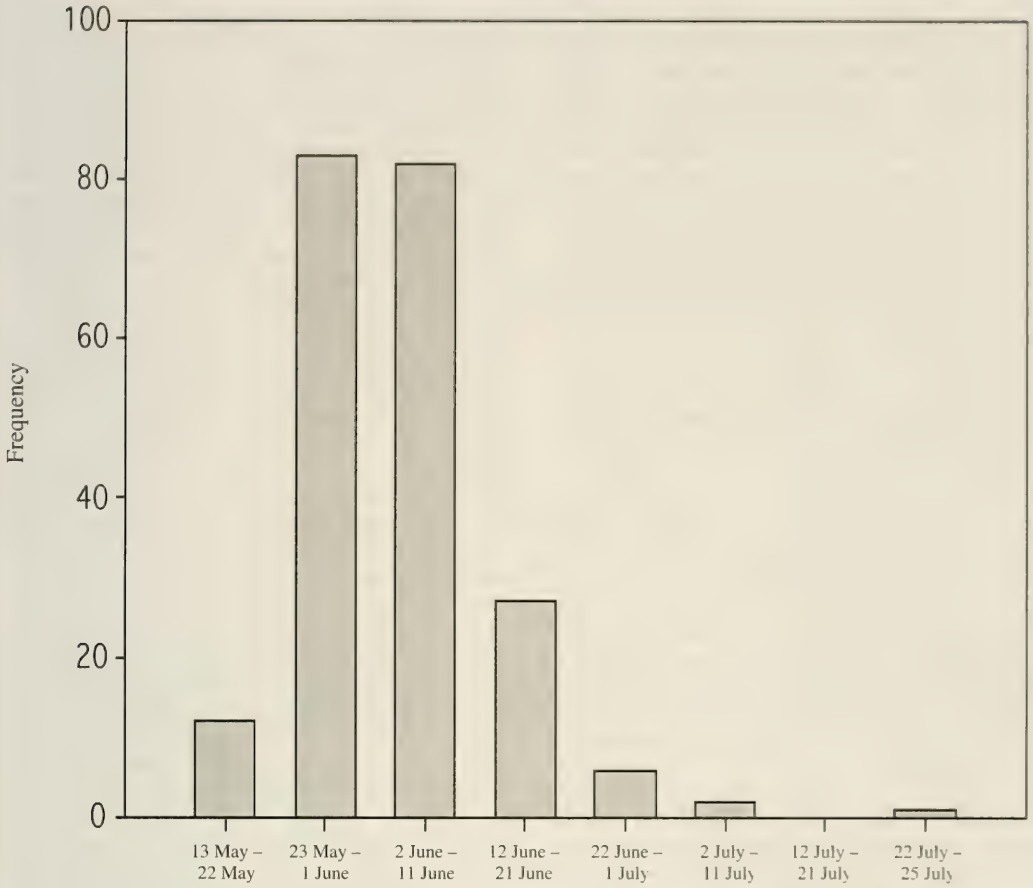

FIGURE 1. Frequency of White-tailed Deer litters in relationship to birth date from 1973 to 1984 (excluding 1974) at the Cusino deer research facility, Michigan, USA.

Body mass of fawns when approximately 9 months of age decreased as birth date became later for males ($F_{4,31} = 5.11$; $P = 0.003$), but not for females ($F_{4,30} = 1.94$; $P = 0.130$; Figure 3). We also did not detect any differences between body mass ($t_{57} = 1.60$; $P = 0.211$), dominance ($t_{56} = 0.00$; $P = 0.973$), or age ($t_{57} = 0.62$; $P = 0.434$) among mothers who produced either males or females.

Discussion

Our results support our hypothesis that offspring sex ratios differ based on birth date in White-tailed Deer. However, we found only moderate support for our hypothesis that more male offspring would be produced earlier in the birthing season as compared to females. Although we were unable to detect a significant difference in the sex ratios of the earliest birthing periods, we did find that more males tended to be born in the second birthing period resulting in a sex ratio different from parity. Although we found only a partial trend for this hypothesis, this trend has been demonstrated in other studies of White-tailed Deer, where it was found that more male offspring were likely to be conceived earlier in the birthing season (S. S. Ditchkoff, unpublished data; W. V. Underwood, unpublished data). In ungulates in a natural environment, individuals that are born earlier have more time to grow and access to more food than late-born conspecifics (Festa-Bianchet 1988; Singh et al. 1990; Festa-Bianchet et al. 1997; Côté and Festa-Bianchet 2001). While an earlier birth could be beneficial to both sexes, fitness gain would potentially be greater for males than females in a sexually dimorphic, polygynous species. Increases in body size and quality have been shown to strongly influence a male's initial reproductive success and lifetime fitness (Suttie 1983; Clutton-Brock et al. 1984; Kruuk et al. 1999; Festa-Bianchet et al. 2000). In addition, early births have also been shown to increase antler quality (Ozoga and Verme 1982; Schmidt et al. 2001; Gray et al. 2002), a trait which strongly affects

dominance and ultimately reproductive success in ungulates (Clutton-Brock and Albon 1980; Bowyer 1986). Also, postweaning male fawns have a greater dietary protein requirement than females (Ullrey et al. 1967). Therefore, being born earlier would be most beneficial for males, since earlier born individuals have better food availability than late born individuals. Female fitness, however, is not as strongly influenced by this initial disadvantage in body size. Jorgenson et al. (1993) found that condition in female Bighorn Sheep (*Ovis canadensis*) did not have a major effect on age at first reproduction. However, they did detect a minimum mass for young ewes to begin reproduction. Variation in mass above this minimum, however, did not effect age at first reproduction. Therefore, producing a particular sex at a certain time has an adaptive advantage for a mother which ultimately increases her lifetime fitness.

In White-tailed Deer, most births normally occur within a short time period (e.g., several weeks). For example, 61% of litters in our population were born during a 15 day period (28 May – 11 June). We expect that in species that have a much longer birthing period or multiple litters within a year, seasonal sex ratio biases would be more prominent. This is true in Virginia Opossums (*Didelphis virginiana*: Wright et al. 1995), Meadow Voles (*Microtus pennsylvanicus*: Dobson and Myers 1989), and Gray-tailed Voles (*Microtus canicaudus*: Bond et al. 2003), and this pattern has been termed the first-cohort advantage hypothesis (Wright et al. 1995). In Virginia Opossums, females had more male-biased first litters than second litters, possibly due to the increased reproductive fitness of males born earlier (Wright et al. 1995). Additionally, in Meadow Voles, more male-biased litters were born earlier in the season than later, corresponding to a similar pattern in litter size, which also declined as the season progressed (Dobson and Myers 1989). On the other hand, Bond et al. (2003), when examining Gray-tailed Voles, found female-biased litters rather than male-biased litters early in the season. They hypothesized that this trend was seen since females almost always reproduce their first year, while most late-born males delay first breeding until the following spring. Additionally, they speculated that winter survival could also influence Gray-tailed Vole sex ratios, where males born later had greater survival through winter than females born at the same time. However, this does not discount the importance of seasonal sex-ratio variation in a species like White-tailed Deer where births are highly synchronized. Our data demonstrate the relative importance of birth dates on female and male condition the following spring in White-tailed Deer. Males born in the earliest birthing period had 18.1% greater mass the following spring at 9 months of age than males born in the last birthing period. Early-born females also tended to have greater mass the following spring than late-born individuals, but the difference between the groups was less (9.7%). Since our study was conducted on a supplementally fed population, we suspect these differences to be less than in a natural population, where food would be limited during the winter months. Although these data do not measure future fitness, they provide strong support for the hypothesis that birth date differentially influences future fitness in males and females, as has been demonstrated in a number of avian species (Smallwood and Smallwood 1998; Pen et al. 1999; Cordero et al. 2001; Byholm et al. 2002; Griggio et al. 2002; Andersson et al. 2003; McIntosh et al. 2003). Despite this apparent trend, we did not detect a larger proportion of males born during the earliest time period. Although we are unsure of the specific reason for this, we suspect that early in the season, resource availability may be unpredictable. While giving birth early has advantages, it could also have disadvantages if food is unavailable or unpredictable at this time. Therefore, it may not be advantageous for females to invest in the more costly sex (i.e., males) if they may not be able to provide adequate nutrition for them. Low sample size during this time period (n = 12) could also have prevented us from detecting this trend.

Another interesting trend seen in our data was that more males were additionally born later in the season. This trend was also seen in American Kestrels, where more male-biased broods were born later in the season, although low sample size precluded statistical analysis (Smallwood and Smallwood 1998). Giving birth late in the season increases the likelihood of producing smaller, disadvantaged offspring of either sex. In Elk (*Cervus elaphus nelsoni*: Smith and Anderson 1998), Red Deer (*C. elaphus*: Clutton-Brock et al. 1987), and Moose (*Alces alces*: Keech et al. 2000) offspring of either sex that were late-born had decreased survival and reproduction. We propose that the best evolutionary strategy for a mother that conceives late may be to produce the dispersing sex. According to the local resource competition hypothesis (Clark 1978), a mother improves her own fitness, as well as that of previous and future offspring that reside within her home range, by producing the dispersing sex, which, by leaving, reduce competition for resources. Our data support this hypothesis, since both males and females born late in the birthing season had low mass the following spring compared to offspring born early. Despite this trend, we were unable to detect a greater proportion of males produced in the last time period, possibly due to the low sample size (9 litters).

Differing sex ratios according to birth date is an overlooked but perhaps very important tactic for increasing lifetime fitness of White-tailed Deer and other polygynous mammals. Although this is not the first documented evidence of seasonal variation in sex ratios in ungulates (Clutton-Brock et al. 1982; Kohlmann 1999) or large sexually dimorphic mammals (Coulson and Hickling 1961; Stirling 1971), we believe our data

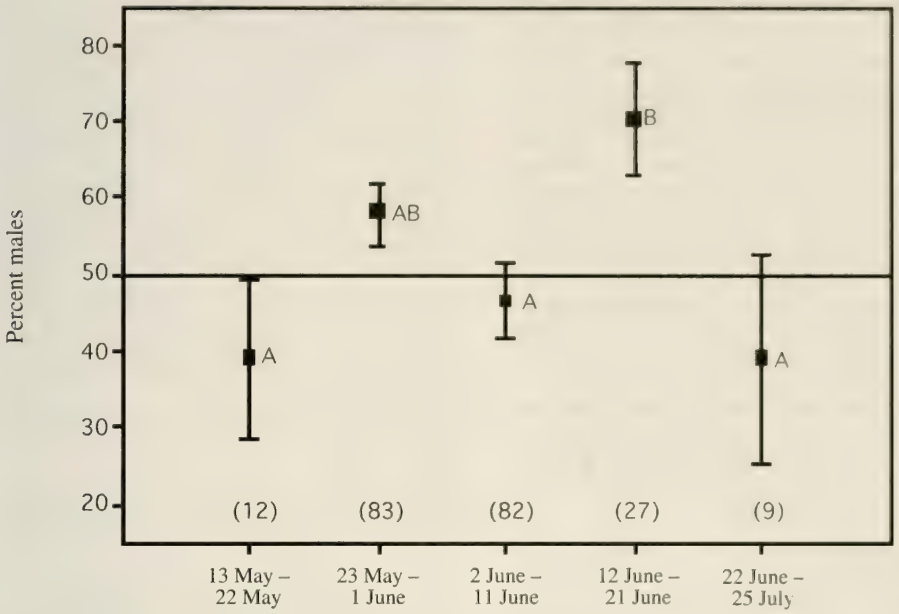

FIGURE 2. Litter sex ratio of White-tailed Deer offspring in relationship to birth date from 1973 to 1984 (excluding 1974) at the Cusino deer research facility, Michigan, USA. Means with the same letters are not different ($P > 0.05$). Numbers correspond to sample sizes of litters in each time period.

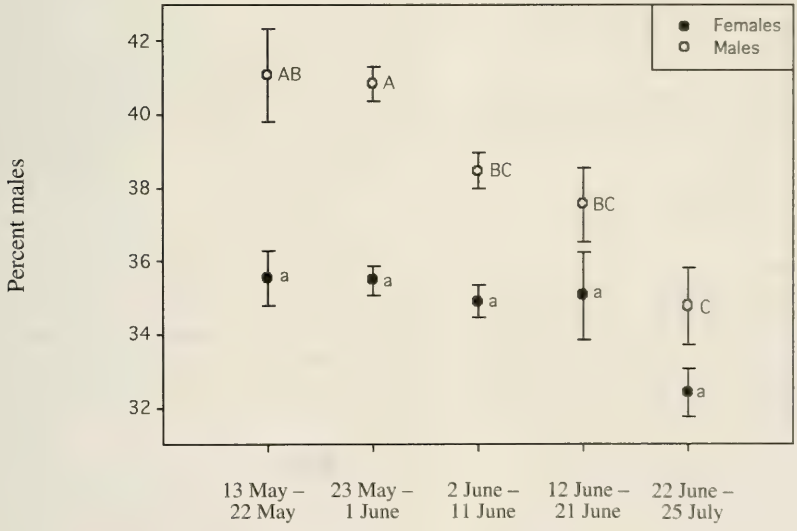

FIGURE 3. Mass of 9-month old male and female White-tailed Deer fawns born in relationship to birth date from 1973 to 1984 (excluding 1974) at the Cusino deer research facility, Michigan, USA. Means with the same letters within an age class are not different ($P > 0.05$).

provides a better explanation for this phenomenon than has previously been proposed. Although there are numerous factors that influence sex ratios and timing of birth, it appears that timing of birth was the main cause of variation in sex ratios in the population we studied. Although our data were collected from a captive herd of White-tailed Deer, we assume that they are representative of a natural population, and since food was provided year round and a stable population was ensured, we expect some of the trends we have noted to be more dramatic in a natural population. This seasonal variation would be most beneficial in species where reproductive success is correlated with initial body mass and therefore birth date of a particular sex. This initial advantage for one sex may be based on a variety of life history traits that differentially affect one sex more than the other such as in sexually dimorphic, polygynous species that exhibit sex-biased competition for mates or territories.

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Notes

Observation of Foliage-roosting in the Little Brown Bat, *Myotis lucifugus*

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Davy, Christina M., and Erin E. Fraser, 2007. Observations of folige-roosting in the Little Brown Bat, *Mytotis lucifugus*. Canadian Field-Naturalist 121(4): 420.

First report of foliage-roosting behaviour in a Little Brown Bat (*Myotis lucifus).* The observation is discussed in relation to similar behaviour in other bat species.

Key Words: Little Brown Bat, *Myotis lucifugus,* foliage roosting, Ontario.

We report the occurrence of foliage-roosting behaviour by a Little Brown Bat, *Myotis lucifugus,* which is generally considered a cavity-roosting species (e.g., Barbour and Davis 1969; Fenton and Barclay 1980; Barclay 1980). At 11:00 hrs on 18 July, 2004, in Algonquin Provincial Park (Ontario, Canada) we observed a single *M. lucifugus* hanging by one foot from a relatively exposed maple leaf (*Acer saccharum*) at a height of about 5 m. The bat was torpid, and would have been well camouflaged had it not been roosting directly opposite a small deck. When captured and handled, it woke from its torpid state within 45 s. and behaved normally. The bat had a number of ectoparasites (bat bugs) on it. However, its ectoparasite load was not higher than the loads observed on several other bats captured in the area, so we have no reason to assume the bat was in poor health.

To our knowledge this is the first time that day-roosting in foliage has been reported for *M. lucifugus,* or any North American *Myotis,* although it is known from other species in the genus (e.g., the Taiwanese endemic *M. formosus*; Y. Ho, personal communication). Other foliage-roosting species in Ontario, such as the larger and more brightly coloured *Lasiurus* species are notoriously difficult to spot in mature forests (Fenton 1998; B. Hickey personal communication), so such behaviour could be easily missed. The Eastern Pipistrelle (*Pipistrellus subflavus)* was previously believed to be an obligate cavity rooster until it was recently found frequently roosting in foliage (Veilleux et al. 2003).

The individual that we observed was less than 100 m from an old building that contained a maternity colony of *M. lucifugus* (>50 individuals), While we cannot discount the possibility that it was a sick or excluded member of the colony, we observed no indications of acute illness. We suggest that our observation represents further evidence that many bat species are capable of substantial behavioural flexibility.

Acknowledgements

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Cowbane, *Oxypolis occidentalis*, A New Native Vascular Plant Species for the Queen Charlotte Islands, British Columbia

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Cheney, Michael, and Kendrick L. Marr. 2007. Cowbane, *Oxypolis occidentalis*, a new native plant species for the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 121(4): 421-422.

We report the recent discovery of *Oxypolis occidentalis*, a species that is new to both British Columbia and Canada, disjunct on the Queen Charlotte Islands.

Key Words: Native vascular plants, new records, *Oxypolis occidentalis*, Cowbane, Apiceae, Queen Charlotte Islands, British Columbia, Canada.

The Queen Charlotte Islands, a group of islands lying off the north coast of British Columbia, continue to yield new and interesting floristic finds. In the summer of 2001, Michael Cheney found a small colony of an unknown Apiaceae growing in and around a series of seepage pools in an old-growth forest margin at approximately 300 m elevation on south-central Graham Island in the Queen Charlotte Islands. A specimen (Cheney *s.n.*; V190944) was sent to the Royal British Columbia Museum (V) for identification, as it did not match any Apiaceae from British Columbia. Here it was identified as *Oxypolis occidentalis* J. Coulter & Rose, using the *Flora of California* (Constance 1993). A specimen sent to the Rocky Mountain Herbarium (RM) (NIS# 2003-133 [DAO]) was also identified as *O. occidentalis* by Ronald Hartman (RM). Specimens were also deposited in the Ministry of Forests herbarium at Smithers (S). Verification of the identification of *O. occidentalis* was based upon the original description (Coulter and Rose 1900) as well as comparison with herbarium specimens (OSU141785, OSU177111, UC177437) from Oregon and California. The Queen Charlotte Islands specimen matches these specimens in the following characters: seed morphology, little variation in ray length, and the size, shape and serration of the leaflets.

Oxypolis occidentalis is new to Canada and belongs to a solely North American genus of six species, found in eastern and western North America and the Caribbean (Constance 1993). In Canada, one other species in this genus has been collected, *O. rigidior* (L.) C. & R., a species of bogs and wet meadows. This species was collected in southern Ontario in bogs, wet woods and swamps, only from 1886 to 1901, and possibly is now extinct (Scoggan 1979).

The closest populations of *O. occidentalis* to the Queen Charlotte Islands populations are approximately 1400 km distant. The northernmost is from eastern Lane County (Oregon Vascular Plant Database Record: ORE103195) in westcentral Oregon as well as Jackson and Lake counties of southern Oregon (Peck 1961). The distribution of collections in California is centred in transmontane California, particularly the high Sierra Nevada and the foothills regions of Fresno, Mariposa, Tulare, and Tuolumne counties from 1200-2600 m in bogs, wet meadows, streamsides and coniferous forests (Constance 1993).

In the summers of 2002 and 2003, 10 other widely-dispersed sites were discovered, revealing that *O. occidentalis* ranges extensively on the south-eastern flank of the Skidegate Plateau in suitable sites from 250-370 m elevation. It is quite possible that it is also found throughout the Skidegate Plateau and in other suitable habitats in the Queen Charlotte archipelago. Only one lowland site has been discovered, at approximately 10 m elevation, 3 km north of Port Clements. Specimens of *O. occidentalis* at this site are confined to a shady area approximately 100 m^2, though this small area is densely populated with *O. occidentalis*.

At the higher elevation sites on the Queen Charlotte Islands, *O. occidentalis* is very frequently associated with *Veratrum viride*, *Senecio triangularis* and *Carex stylosa*. The lowland population is associated with *Angelica genuflexa, Carex cusickii, Lysichiton americanus, Menyanthes trifoliata,* and *Oenanthe sarmentosa*. The known distribution of the populations on the Queen Charlotte Islands, along with its narrow habitat preferences and its presence in forests that have not been logged or otherwise disturbed by humans, suggest that it is not a recent introduction. Whether *O. occidentalis* is also found in some of the many suitable habitats on Moresby Island remains, for the moment, an intriguing question and one that may shed some light on its status as a native species of the Queen Charlotte Islands.

The existence of a disjunct Queen Charlotte Island population of *O. occidentalis* raises biogeographical questions. Queen Charlotte Islands specimens of *O. occidentalis* are being examined using molecular techniques at the University of Illinois as part of a systematic and phylogenetic treatment of the genus. The results of this investigation should contribute further to an understanding of the biogeographical relationships between the Queen Charlotte Islands populations and those further south.

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Apparent Predation of an American Water Shrew, *Sorex palustris*, by an American Marten, *Martes americana*

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Todd Powell, Thomas S. Jung, and Karen J. Clyde. 2007. Apparent predation of an American Water Shrew, *Sorex palustris*, by an American Marten, *Martes americana*. Canadian Field-Naturalist 121(4): 422-423.

Little is known of the natural history of American Water Shrews, *Sorex palustris*, including their predators. We document an apparent case of predation of an American Water Shrew by an American Marten, *Martes americana*, in the boreal forest of southeastern Yukon.

Key Words: American Marten, *Martes americana*, American Water Shrew, *Sorex palustris*.

Little is known of the natural history of the American Water Shrew (*Sorex palustris*). For example, incidents of predation are rarely noted, despite the fact that the relatively large size of its skull should be easy to identify in the stomachs, scats, or pellets of predators. The American Water Shrew is semi-aquatic and the vast majority of records are from within several metres of a waterbody (Benenski and Stinson 1987, Nagorsen 1996). As such, most non-volant predators of American Water Shrews are aquatic or semi-aquatic, including large frogs, snakes, and fish (Benenski and Stinson 1987; Nagorsen 1996). The American Mink (*Neovison vison*) is the only reported mammalian predator of the American Water Shrew (Benenski and Stinson 1987), and it also is semi-aquatic. We are not aware of any observations of terrestrial mammals preying upon American Water Shrews. Here, we provide an observation of apparent predation of an American Water Shrew by a terrestrial predator, the American Marten (*Martes americana*).

Our observation was made during a live-trapping study of American Marten near Watson Lake, Yukon (60.2°N, 128.7°W). On 13 July 2006, we captured an American Marten and found a dead shrew at the entrance of the trap. The shrew was identified as an American Water Shrew using the key provided by Nagorsen (1996). The trap site was in upland boreal forest, about 350 m from the nearest waterbody.

We surmise that the Marten was carrying the Water Shrew and dropped it prior to entering the trap. Alternatively, the Water Shrew may have been feeding on the bait in the trap, where the Marten found it and killed it. The latter hypothesis is not likely, however, because the Water Shrew was found outside the trap; for this hypothesis to be more plausible then the Water Shrew should have been found inside the trap. Therefore, we believe that the Marten killed the Water Shrew before it had entered the trap. It is not known, however, if the Marten would have consumed the Water Shrew.

Several studies of food habits of American Marten have reported that shrews are among the least preferred prey item of American Marten (e.g., Cowan and Mackay 1950; Quick 1955; Douglass et al. 1983; Slough et al. 1989; Thompson and Colgan 1990; Nagorsen et al. 1991; Simon et al. 1999). All shrews found in the stomach contents or scats of Marten have been terrestrial species (e.g. *S. cinereus*, *S. hoyi*, *S. monticolus*). Our observation adds the American Marten as a likely predator of the semi-aquatic American Water Shrew.

We do not know where the Marten killed the Water Shrew, but we find it interesting that the Marten may have killed the shrew while it was away from a waterbody. On 8 July 2006, we found a dead American Water Shrew about 400 m from a small pond near Whitehorse, Yukon (60.5°N, 135.1°W) that was killed by a tethered sled dog. In another instance, on 20 September 2005, we trapped an American Water Shrew in a pitfall trap in a clearcut near Watson Lake, Yukon, that was 1.1 km from water. Other observations of American Water Shrews away from water have been noted (e.g., Kinsella 1967; Wrigley et al. 1979). Taken together, these observations suggest that American Water Shrews may make overland movements, and

that they may be susceptible to mortality during these movements, including predation.

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Giant Pacific Octopus, *Enteroctopus dofleini*, Attacks on Divers

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Anderson, Roland C., Ronald Shimek, James A. Cosgrove, and Steve Berthinier. 2007. Giant Pacific Octopus, *Enteroctopus dofleini*, attacks on divers. Canadian Field-Naturalist 121(4): 423-425.

Documentation is given of four instances of attacks on scuba divers by the giant Pacific octopus.

Key Words: Giant Pacific Octopus, *Enteroctopus dofleini*, Mollusca, Cephalopoda, attacks, Washington, British Columbia.

In the cold waters around the North Pacific live some truly giant animals. Among them, individuals of one octopus species, *Enteroctopus dofleini* (Wülker, 1910) have been documented to weigh over 68 kilograms (150 pounds) (Cosgrove 1987), making it the world's largest octopus (Norman 2002). Although octopuses (the now preferred plural) have been portrayed as monsters in fiction, folklore, and movies such as *It Came from Beneath the Sea*, octopuses are, as a whole, not monsters, but interesting and intelligent creatures (Mather and Anderson 1993, 1998*). Although predatory, they are generally shy and retiring animals that would rather retreat to a den than have any contact with humans (Hartwick 1983; Hanlon and Messenger 1996). We have emphasized "as a whole" and "generally" because octopuses, particularly the larger, more experienced ones, are individuals (Anderson and Wood 2001). As should be expected with individuals, they may show decided differences in how they react to any given situation. Sometimes divers will encounter a large octopus that is bold and aggressive rather than shy. The motivations for aggression in normally docile animals are unknown. It is possible that these animals may want to see if a diver has food or frankly, they may well be considering that the diver is food. Whatever the cause, we here relate four instances of octopus attacks on divers.

Fishy Business

A diving crew from the Seattle Aquarium was collecting animals near Slant Rock on the outer coast of Washington State. With rocky cliffs plunging dramatically into the cold Pacific, this is one of the more picturesque areas in a beautiful state. Upwelling at the entrance to the Strait of Juan de Fuca keeps water clear and as cold as 4.4°C (40°F) in the summer! Six meter

(twenty foot) swells are common and the vigorous wave action on the rocks keeps the water well-oxygenated making it prime octopus habitat. While common, mature male octopuses in this area are generally small, weighing 14 kg (30 pounds) or less; in nearby Puget Sound mature male octopuses are commonly 27 kg (60 pounds) or heavier.

The team was collecting adult rockfish with a barrier net. Two divers direct the fish into the net, where they are captured. A third diver bags the fish caught in the net. On this occasion the bagger noticed that a small octopus, having an arm span of about 2.4 meters (8 feet) and an estimated weight of about 6.8 kg (15 pounds), had crawled onto the net and had "flared" across it. When the two other divers returned, the octopus reached out to each and held onto them, one at a time. It actually pulled off one diver's dry suit glove, causing him great aggravation as the cold water leaked up his sleeve. The divers gently pushed the octopus away knowing, from past experience, that this should be enough to scare it off. They then picked up their gear and moved to a different nearby area. While floating in the water 1.5 or 1.8 meters (5 or 6 feet) off the bottom, they were surprised to see the octopus crawling across the bottom toward them. It attacked them again, doing a flaring webover pounce on each of them. When one diver had wrestled it off, it moved to another diver and repeated the behavior. The divers could not get rid of the animal. This so broke up their concentration they decided to surface to the support boat overhead, laughing about the horrible octopus attack!

Now, a 6.8 kg (15 pound) octopus is by no means a monster. The attack these veteran divers experienced was no worse than a puppy worrying a shoelace. But as a puppy might chew through an electrical cord, so might a small octopus do damage in an encounter with a diver. A giant Pacific octopus has a formidable beak that could tear a diver's suit or flesh (Snow 1970; Anderson 1999). The octopus can also inject a venomous saliva into a bite (all octopuses are venomous) (Hanlon and Messenger 1996). However, if a big octopus were to attack a novice diver, the outcome could be different. Instead of surfacing laughing, the diver might not surface at all. The following anecdotes of octopus attacks are more serious and the outcome could have easily been tragedy but for the experience and professionalism of the divers plus some good luck.

Kick Me, Will You?

The second incident happened at Small Pox Bay on the San Juan Island in Northern Puget Sound. Two divers were swimming out into the bay from the shore. One diver was about 3 meters (10 feet) ahead of and above his partner. He looked back at his buddy and saw him kick a big rock. Immediately the "rock" changed color to white then dark red! It was a large octopus, at least 3 meters (10 feet) across its arms. The animal extended one arm over the unaware diver's fins and ankle, immobilizing him. His forward velocity ceased and, severely startled, he attempted to rise up in the water. He was securely held by the octopus clinging to him and onto the rocks beneath it. The diver grabbed his dive knife and slapped at the octopus' arm. The mollusk responded by wrapping another arm around the diver's legs. He again attempted to ascend and did rise a bit, but the octopus was now moving up toward him by shortening the arms holding the diver and lengthening the arms anchored to the rock beneath it. The diver was working hard enough that a steady stream of air came out his regulator; no discrete breaths were noticeable. The diver approached a nearby cliff and picked up a boulder. The diver attempted to drop it on the large mollusk but just as he did so, the octopus let go, jetted to the bottom and swam off rapidly. During the approximately two minutes of the encounter, the victim had exerted enough effort in trying to break free of the octopus that he had just 20% of his breathing gas (600 psi) left in his tank. His buddy's tank had 67% (2000 psi) remaining. This attack appeared to be the result of simple aggravation at being kicked.

I Don't Like Your Looks

At the Keystone Jetty on Whidbey Island, Washington, a diver was signaled by his buddies to come see a large octopus sitting in front of its den. As he swam over, the octopus turned and faced this diver for a moment then it rapidly swam toward him. The diver used his camera to fend it off. This worked for a while. The animal then pulled on his camera, tugging on the strobes, strobe arms and whole assembly before moving to the diver himself. At first the diver thought: "This is cool, it's going to check me out," then he felt it pulling his mask off. Suddenly it was decidedly "uncool." He grabbed what he could on the bottom and pushed the animal off, holding tight to his mask and biting tightly to hold on to his regulator. The octopus finally let go and retreated back to its den after the diver's buddies shone an ultra-bright canister light at it.

"Come Into My Parlor," Said the Spider to the Fly...

The next attack occurred in Saanich Inlet on Vancouver Island, British Columbia. The diver was a scientist working for a crew filming octopuses. The scientist was very experienced at handling and being around octopuses. He had enticed an octopus to leave its den and the film crew went off with it. As the diver, now alone, gathered his equipment, a second octopus came out of an unseen den. After looking at the diver for a moment, the octopus crawled quickly to the diver's chest and, while remaining firmly anchored to the rocks below with several arms, it seized his upper arms, chest and head. The octopus got three suckers onto the

diver's bare forehead and wouldn't let go. The pressure from the suckers created bruises that lasted for about a week. During the roughly three-minute struggle the diver fought to keep his regulator in his mouth by biting down hard on the mouthpiece and using both hands to cover it. The diver eventually outlasted the octopus but in the struggle lost his mask, had his hood pulled partially off and had his dry suit flooded. As might be expected, he also used up a significant amount of breathing gas. The octopus finally gave up on this test of strength and let go. The diver felt that, had he lost his regulator or had he been low on air, he would have undoubtedly died. The octopus was just too strong for him to do anything but hang onto his regulator and brace himself from being pulled into the den.

Some Thoughts

Most large octopuses are "pussycats." Usually, the larger they are, the more placid and relaxed they are. But as these experiences indicate, there are exceptions. At certain stages in their lives, octopuses are lean, mean, eating machines. They can put on 2% of their body weight per day (Hartwick et al. 1981; Cosgrove 1987) so they are constantly looking for food. "Checking out a diver" with chemotactic suckers may simply be seeing if he or she is edible. As far as we know, the octopuses will let go when they find they cannot subdue a diver, or the diver is not edible, but the diver needs to remain calm and keep a tight grip on his or her regulator. So far, we can document no case of a Giant Pacific Octopus attack that has resulted in a diver fatality, but there have been diver deaths where no cause is found to explain the tragedy. Perhaps octopuses were involved in these deaths but even it they were not it is wise for all divers to be respectful of the potential danger of these powerful animals.

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Details of Eastern Coyote, *Canis latrans,* Predation on Great Black-backed Gull, *Larus marinus,* Eggs on Boot Island National Wildlife Area, Nova Scotia

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MacKinnon, Colin M., Andrew C. Kennedy, and Donald W. Colpitts. 2007. Details of eastern Coyote *Canis latrans* predation on Great Black-backed Gull *Larus marinus* eggs on Boot Island National Wildlife Area, Nova Scotia. Canadian Field-Naturalist 121(4): 426-428.

We detail field observations of Eastern Coyote eating Great Black-backed Gull eggs for the first time in the literature. Photographic evidence of the remaining egg shells allowed us to identify the Coyote as the predator.

Key Words: Eastern Coyote, *Canis latrans*, Great Black-backed Gull, *Larus marinus*, seabird, egg predation, Boot Island National Wildlife Area, Nova Scotia, Canada.

Parker (1995) discussed in detail the recent colonization of eastern Canada by the Eastern Coyote *Canis latrans*. The coyote arrived in New Brunswick from Maine around 1970 and this expansion continued eastward; it was found in mainland Nova Scotia by 1980 and on Prince Edward Island by 1983. Studies of coyotes in eastern Canada have reported that White-tailed Deer (*Odocoileus viginianus*) and Snowshoe Hare (*Lepus americanus*) are important prey species (Moore and Miller 1986; Parker 1986; Morton 1988; Patterson and Messier 2001). However, throughout their range Coyotes are opportunistic and have a diversified diet (Berg and Chesness 1978; Parker 1995). In recent years, tracks and scats of coyotes have been found on a number of off-shore islands in eastern Canada including areas important to nesting seabirds (MacKinnon et. al. 2006*). However, actual detailed descriptive information on coyote depredation on seabirds (adults, eggs, or chicks) is generally lacking in the literature.

Colonial nesting birds typically prefer remote islands to escape terrestrial predators and mammalian disturbance. One such colonial seabird colony is located on Boot Island, Kings County, Nova Scotia (45°08'N, 64°16'W). Boot Island is a 144 ha protected area (Boot Island National Wildlife Area) consisting of 135 ha of saltmarsh and two upland islands adjacent to the marsh. The smaller island (0.5 ha), referred to as "Cyril's Island", is surrounded by saltmarsh and is located along the northwest border of the NWA. The main island, Boot Island proper (8.5 ha), is bordered by saltmarsh to the southwest and 5 m cliffs to the northeast. Boot Island and Cyril's Island are predominantly long-abandoned farm land (6.5 ha) dominated by two species of wild mustard – Wild Radish, *Raphanus raphansitrum,* and Hairy-pod Hedge Mustard, *Sisymbrium officinale*. The highest ground is dominated by a small area (2.0 ha) of dead and dying White Spruce, *Picea glauca,* with an understory of predominantly Red Elderberry, *Sambucus racemosa,* (Newell et. al. 2006). The western side of Boot Island is separated from the nearest mainland by a narrow creek (340 m across water at low tide).

In 2006, the island supported the following colonial-nesting birds: Great Black-backed Gull, *Larus marinus*; Double-crested Cormorant, *Phalacrocorax auritus*; Great Blue Heron, *Ardea herodias*; and Herring Gull, *Larus argentatus*, with 943, 151, 52 and 22 breeding pairs, respectively (MacKinnon et. al. 2006*). The heron and cormorant nests were in trees and restricted to the forested area while the Great Black-backed Gull nests were scattered throughout the old field habitat. Herring Gull nests were relegated to a few small pockets within the much larger Great Black-backed Gull colony.

Evidence of Coyote activity (tracks and scats) had been recorded on earlier visits to Boot Island (personal observations). On 10 May 2004, the authors directly observed a Coyote in the act of egg depredation. We arrived on the island near high tide, around 06:50 AST, and began a nest survey of the gull colony. By 12:50, the survey was completed and C. M. M. and D. W. C. were at the extreme northwestern edge of the main island. At that time we observed a Coyote walking towards us in an easterly direction, across the saltmarsh. Its coat was wet (the day was sunny and clear, 14°C) suggesting the animal had just swum across the narrow creek between Boot Island and the mainland. When the coyote was first observed, D. W. C. was sitting on the shore behind a large piece of driftwood, and C. M. M. was standing, in full view, in the saltmarsh just east of Cyril's Island, about 100 m from D. W. C. Observations of Coyote behaviour were made at ~ 50 m using 10 × 40 Leitz Trinovid binoculars. The Coyote proceeded east, passing within 25 m of the senior author, before changing direction towards the gull colony on the main island. Upon reaching the high water mark on the main island (site of the Great Black-backed Gull colony), the Coyote slowed and purposefully hunted the upper edge of the seaweed

Figure 1. Dimple marks made by Coyote's teeth (probably the premolars) when carrying a Great Black-backed Gull egg, Boot Island National Wildlife Area, Nova Scotia, 2004. (A. Kennedy photo)

Figure 2. Lateral 'slice' made by the canine teeth of a Coyote to open a Great Black-backed Gull egg, Boot Island National Wildlife Area, Nova Scotia, 2004. (A. Kennedy photo)

"wrack" line apparently searching for gull nests. It immediately encountered a Great Black-backed Gull nest, picked up an egg with its mouth and carried it a few meters carefully cradled in its jaws, before slicing it open and eating the contents. Upon seizing the egg, the Coyote left several small tooth impressions (indentations), next to each other, on one side of the egg (Figure 1). The Coyote opened the egg by positioning it in its jaws allowing one side of its canine teeth to make a "slice" across the thickest portion (Figure 2). As a result of this lateral cut through the egg, the shell fragments along the edge of the slice appeared oriented in the direction of the cut as opposed to facing uniformly inward as would be expected from a puncture. The Coyote then dropped the damaged egg on the ground, spilling the contents (mostly yolk) into the grass where it was quickly lapped up. The Coyote consumed a number of eggs (> 5) from different nests in the same manner. It then continued eastward, away from our point of observation, presumably predating more nests and paying little attention to the observers or the hundreds of very vocal Great Black-backed Gulls. The Coyote was of average size (~15 kg) and appeared to be healthy and in good physical shape.

The process of how the Coyote opened the gull eggs prior to consuming the contents, as well as the telltale marks left on the egg remnants, was not expected. Had we encountered similar broken gull eggs, without knowing that they had been depredated by a Coyote, we probably would have attributed this predation to American Crow, *Corvus brachyrhynchos*, or Common Raven, *Corvus corax*. are frequently observed foraging in seabird colonies and depredated eggs with puncture marks are routinely attributed to these birds by researchers. Causes of predation are particularly important if one is trying to determine survival rates of eggs of various seabird species.

The gull colony on Boot Island National Wildlife Area has been declining in recent years with a near linear decrease in Herring Gull nests from 727 in 1986 to only 22 in 2006 (MacKinnon et al. 2006*). Great Black-backed Gulls have also experienced a less drastic, although similar, decline. It is as yet unclear to what extent Coyote predation may have on the decline in gull numbers being observed on Boot Island. This note provides recognizable characteristics on depredated gull eggs which may help identify egg loss from Coyotes versus other predators.

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Red-breasted Nuthatch, *Sitta canadensis,* Dies Stuck in Resin at Entrance to a Nest-box

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Strauss, Clive F. 2007. Red-breasted Nuthatch, *Sitta canadensis*, dies stuck in resin at entrance to a nest-box. Canadian Field-Naturalist 121(4): 428-429.

I document a female Red-breasted Nuthatch (*Sitta canadensis*) found dead and stuck to resin in the opening of a nest-box in an urban setting. This is the second reported occurrence of such mortality and the first involving a nest-box. This species applies resin to its nest openings to deter predators and reduce competition or parasitism from other species. Red-breasted Nuthatches infrequently utilize nest-boxes. At necropsy this female nuthatch was found to be carrying a fully-formed egg with shell and this increase in abdominal girth may have contributed to her demise.

Key Words: Red-breasted Nuthatch, *Sitta canadensis*, mortality, resin, nest-box, British Columbia.

On 12 April 2007 I found a dead female Red-breasted Nuthatch (*Sitta canadensis*) stuck in the opening of a nest-box about 5 m above the ground under the west-facing eaves of a city residence in Victoria, British Columbia (48°20.0'N, 123°22.0'W). The entrance of the nest-box was covered by a hard transparent acrylic plate, measuring 6.7 × 6.0 cm with an oval entrance hole of diameter 3.4 × 3.0 cm, designed to exclude House Sparrows (*Passer domesticus*). Earlier a Chestnut-backed Chickadee (*Poecile rufescens*) was seen building a nest in this nest-box, and it was often interrupted by a Red-breasted Nuthatch pecking at the opening and calling persistently.

Extraction of the dead nuthatch resulted in numerous chest and abdominal feathers remaining stuck in the entrance hole of the nest-box (Figure 1). It was observed that the acrylic plate was irregularly covered in sticky resin that had an odor suggestive of a coniferous tree. The interior of the box revealed a newly built chickadee nest made out of moss but devoid of eggs. Subsequent to the removal of the dead bird, a pair of Red-breasted Nuthatches was seen "excavating" this nest-box by removing moss. In previous years, Violet-green Swallows (*Tachycineta thalassina*) successfully raised broods in this nest-box. The acrylic plate was added only after House Sparrows killed several swallow nestlings.

Several observers in British Columbia (Campbell et al. 1997) and elsewhere (Bent 1948; Ghalambor and Martin 1999) have reported Red-breasted Nuthatches daubing resin around the entrance of their nest holes, it is thought, to protect the nest against competition from other cavity-nesting birds or mice, as well as against predation by other species or insect parasitism. In most cases this seems to pose little risk to the nuthatch itself but seems to deter competitors (Ghalambor and Martin 1999). Daubing nest entrances and cavities with mud or insects is known for other *Sitta* species (Pasquet 1998).

A literature search of the nesting behaviour of the Red-breasted Nuthatch revealed only one previous report of death at the entrance of nest hole: Kilham (1972) reported a dead female Red-breasted Nuthatch found stuck to the resin in the entrance of a tree cavity. Red-breasted Nuthatches infrequently utilize nest-boxes. Dunn et al. (1975) described two nest-boxes utilized out of 100 designed for Black-capped Chickadees (*Poecile atricapillus*) in a pine plantation on the north shore of Lake Erie. Those nest-box entrances were also heavily daubed with pine (*Pinus* sp.) resin. Nest-box sites were utilized in only two out of 143 nests in British Columbia reported by Campbell et al. (1997). The Cornell Laboratory of Ornithology recommends a circular nest-box entrance hole with a diameter of 3.2 cm for Red-breasted Nuthatches (Cornell Lab of Ornithology, The Birdhouse Network. Habitat Requirements Available: www.birds.cornell.edu/birdhouse/bios/nestrequire/habitat. [Accessed 1 May 2007]). The hole in the cover plate in this instance measured 3.4 × 3.0 cm.

The dead Red-breasted Nuthatch was found to contain a complete egg with shell as well as three develop-

FIGURE 1. Photograph of the acrylic nest-hole cover (removed from the nest-box) with an oval entrance hole of diameter 3.4 × 3.0 cm, showing the Red-breasted Nuthatch feathers stuck to sticky resin on the lower half.

ing ova in the ovary. It is possible that the increased abdominal girth of this gravid female nuthatch contributed to her getting trapped and subsequent demise

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Attempt to Cross-Foster Gray Wolf, *Canis lupus*, Pups into Another Wolf Pack

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We attempted to cross-foster four 18-19 week-old Gray Wolf (*Canis lupus*) pups into another Wolf pack 182 km from their natal pack territory. The pup introduction was the result of depredation control on a farm in northwestern Wisconsin. Three pups died within 14 days of release. A fourth pup survived along the edge of the new pack territory over winter, dispersed in the spring, joined or formed a new pack and was captured on a depredation complaint four years later.

Key Words: Gray Wolf, *Canis lupus*, introduce, depredation, natal pack, Wisconsin.

Depredation control programs on Gray Wolves, (*Canis lupus*) may create concern about how to humanely deal with wolf pups captured at depredation sites. Such problems can be especially acute when lethal controls are not allowed.

It has been demonstrated that Black Bear (*Ursus americanus*) cubs have been successfully introduced to other female bears (Carney 1985). Cross-fostering of week-old captive Coyote (*Canis latrans*) pups was highly successful (Kitchen and Knowlton 2006). Cross-fostering has been successful in captive Red Wolves (*Canis rufus*) with all fostered wolves surviving to weaning (Waddell et al. 2002*), and has been successful for captive Gray Wolves (*Canis lupus*) (Goodman 1990). Two captive-born Red Wolf pups were fostered into a wild wolf den containing two pups of identical age in 2002 (U. S. Fish and Wildlife Service 2004 Fostered red wolf recaptured and released. Red Wolf News 5: 2, US Fish and Wildlife Service, Manteo, North Carolina, Unpublished report). Two 6-month-old pups that were given standard soft releases in separate translocation incidents remained cohesive with adult pack members after release and survived (Bradley et al. 2005). In Wisconsin a wolf pup was successfully reintroduced back into its natal pack after 53 days in captivity (Schultz et al. 1999).

However, not all cross-fostering pup translocation attempts have been successful. An attempt was made to cross-foster six 3 to 4-week-old Mexican wild wolf pups (*Canis lupus baileyi*) to a surrogate adult pair at the Sevilleta National Wildlife Refuge Mexican Wolf Management Facility that had two pups, but they were rejected and killed by the adult male (Mexican Blue Range Reintroduction Project Monthly Update 1 – 31 May 2006. Unpublished report). Two hard release translocation events, including three 5-month-old pups in northwestern Montana resulted in abandonment by adult members after release, and the pups died soon thereafter (Bradley et al. 2005).

To our knowledge there have never been any attempts made to cross-foster 18 to 19-week-old weaned free ranging wild Gray Wolf pups into another wild wolf pack. We describe an experimental cross-fostering of wild post-weaning Gray Wolf pups at an age before they began accompanying adults on hunts (Mech 1970) into another pack territory in Wisconsin during a time when translocations were used to deal with problem wolves.

Methods

Four 13 to 14-week-old Gray Wolf pups, two females (F390, F393) and two males (M391, M392) were captured on a farm in northwest Wisconsin where cattle were being killed by wolves. Wolf M392 was captured on 25 July, M391 on 27 July, F390 on 30 July, and F393 on 31 July 2001. A lactating adult female, F367 was previously caught on this farm on 26 May 2001, and released with a shock collar (Schultz et al. 2005) 5.3 km from the farm because she was likely nursing a litter of pups. Three other wolves (one yearling male, one adult male, one adult female) were also captured at the farm in August and were translocated 260 km from the farm. In previous years, two different wolf packs bordered the farm: the River Side Pack to the east and Chases Brook pack to the north and west. We were unable to determine which pack the pups came from and were concerned the pups might be abandoned if translocated with the adults, so they were transported to a holding pen 174.8 km from their capture site.

The holding pen consisted of a 3 m2 enclosure with an artificial den (46 × 81 × 61 cm) placed 0.3 km from the nearest human dwelling. The four pups were fed a mixture of 60% venison, 40% dry dog food (Tuffy's, Division of H. J. Heinz, Perham, Minnesota 56573, USA). All four pups were given a 0.5 ml injection of Gentocin (Schering-Plough Animal Health Corp. Kenilworth, New Jersey 07033) daily for 21 days to treat trap-related injuries.

On 16 August 2001, a White-tailed Deer (*Odocoileus virginianus*) carcass was placed by a rendezvous site commonly used by the Bootjack Lake Pack (BJLP). On 20 July 2001 pups and adult wolves responded on a howling survey from the rendezvous

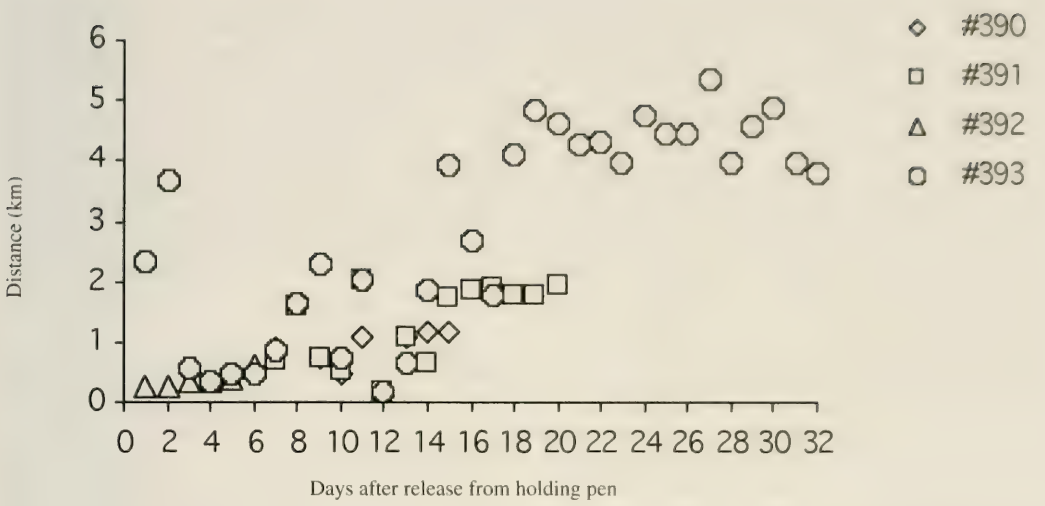

FIGURE 1. Daily distance pups F390, M391, M392 and F393 moved from holding pen, (28 August to 29 September 2001).

site and on 21 July 2001 an industrial forest employee saw one gray and three black wolf pups 200 m southeast of the rendezvous site.

On 19 August 2001 a new holding pen of the same size was erected 30 m from the deer carcass drop site, next to the rendezvous site. On 20 August 2001 all four pups were weighed (10.9 – 11.8 kg) and fitted with radio tracking collars (Telonics Inc., Mesa, Arizona 85204-6699 USA). The radio collars were lined with Rockford 3319 foam rubber (Rockford Supply Inc. 1500 Washington Avenue, North Minneapolis, Minnesota 55411) to compensate for neck growth. The four pups were then transported to the new holding pen, and another deer carcass was dropped off. Three adult wolves from the BJLP spontaneously howled while the pups were being placed in the new pen.

On 28 August 2001, all four pups were given a 1-ml external treatment of Revolution (Pfizer Animal Health Exton, Pennsylvania 19341, USA, Division of Pfizer Inc., New York 10017) and 0.5-ml subcutaneous injection of Ivermectin (MSD-AGVET, Division of Merck & Co., Rahway, New Jersey 107065, USA) to kill a heavy infestation of lice (*Trichodectes canis*).

Wolves F393 and M392 were released from the holding pen on 28 August 2001, and wolves F390 and M391 were released on 3 September 2001. Venison and dry dog food were placed in the holding pen every day for the next five days. Deer carcasses were dropped off every 2-3 days for the next 17 days. All pups were located one or more times daily for the first 32 days after release and one or more times weekly thereafter.

Necropsies on all pups that died were performed by wildlife disease specialists and pathologists at the United States Geological Survey (USGS) National Wildlife Health Center in Madison, Wisconsin.

Results

The pups repeatedly returned to feed on the deer carcasses and remained within 4.0 km of the release site for the first 14 days (Figure 1). Adult wolf tracks were observed at the deer carcasses on 5 and 8 September 2001, and on 9 September 2001 an adult wolf was observed by the deer carcass drop site, confirming members of the BJLP were visiting the site.

On 3 September 2001, wolf M392 was found dead 0.4 km from the holding pen. The body was partially submerged in water on the edge of a small marsh. His carcass looked to be in good condition, did not have any external wounds, and had gained 1.5 kg from when he was collared. Necropsy results revealed congested lungs, and death probably due to bacterial pneumonia (USGS, National Wildlife Health Center, Case 17366). On 12 September 2001, wolf F390 was found dead 1.1 km from the holding pen at the edge of a northern White Cedar (*Thuja occidentalis*) swamp. F390 had deep puncture wounds to the head and throat, and a fractured skull and ribs. F390 had gained 2.4 kg from when she was collared (USGS, National Wildlife Center, Case 17394). Adult male wolf M336 of the BJLP was located at the same location as F390 on 10 September 2001, so it was assumed he or other pack members may have killed the pup.

On 17 September 2001, wolf M391 was found dead 1.9 km from the holding pen on an old Beaver (*Castor canadensis*) dam. M391 had superficial puncture wounds to the throat and lower jaw. The superficial wounds may have occurred on 10 September 2001 when M391 was located near F390 and M336. Necropsy results revealed congested lungs and death probably due to bacterial pneumonia (USGS, National

Health Wildlife Center, Case 17395). M391 had gained 2.8 kg from when he was collared. The average weight gain of all three pups from release date until their deaths was 0.21 kg per day. This was double the standard weight gain of 17 wild-caught female wolf pups (Van Ballenberghe and Mech 1975).

Wolf pups F390, M391 and M392 stayed within 1.9 km of the release pen until their death. Wolf pup F393 moved 3.7 km from the release site two days after being released but returned 3 days later. She remained within 2.7 km of the release site until 15 September 2001, when she moved 4.1 km (figure 1) and stayed within a 3.5 km2 area until 4 December 2001. She then moved 23.2 km southwest of the holding pen. Pilots observed F393 with two other wolves on 8 January 2002, but she did not appear to establish a new territory during the winter of 2002.

In spring 2002, wolf F393 dispersed westward and by summer had settled into the Long Lake Pack area 106 km southwest of the Bootjack Lake Pack. On 1 August 2005, wolf F393 was captured and euthanized on a depredation complaint. Five placental scars were observed on F393 necropsy, confirming she apparently raised pups in 2004 and 2005 (USGS, National Wildlife Health Center, Case 19680).

Discussion

The cross-fostering attempt was not successful, but one pup (25%) of the four did survive and eventually joined up with other wolves. This pup remained alive, but abandoned the Bootjack Lake Pack's territory. None of the pups joined the new pack, and three died within 15 days of release. Two of the pups (50%) had injuries which were assumed to have been inflicted by Wolves from the BJLP. The cross-fostering attempt might have been more successful if the pups had been introduced to a pack adjacent to their natal pack's territory where there may have been some interaction between packs (Hamilton 1964). Perhaps if the pups had been placed in the BJLP's territory earlier and kept in the holding pen longer, the BJLP wolves would have become more bonded to them (Bradley et al. 2005). We also assume that pup mortality may be high on this type of introduction, as in bears, and should only be attempted under extreme circumstances.

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Abandoned Seabird Eggs as a Calcium Source for Terrestrial Gastropods

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Bond, Alexander L., and Antony W. Diamond 2007. Abandoned seabird eggs as a calcium source for terrestrial gastropods. Canadian Field-Naturalist 121(4): 433-435.

Birds' use of terrestrial gastropods to supplement calcium for egg formation has been well documented, but the reverse, gastropods using avian eggshells as a calcium source, has not been recorded previously. We collected Arctic Tern, *Sterna paradisaea*, eggs, abandoned in July 2006, that were found to have many terrestrial gastropods on the surface, and it appeared as though the outer eggshell layers were removed. Using scanning electron microscopy, we compared "grazed" and "ungrazed" sections of the same shell with eggshells collected in 2005 that were not attended by snails. It appears as though the snails removed the outer eggshell layers, presumably to supplement their own shell growth.

Keywords: Arctic Tern, *Sterna paradisaea*, White-lip Gardensnail, *Cepaea hortensis*, Glossy Pillar, *Cionella lubrica*, calcium, eggshell, New Brunswick

Although is it true that birds may seek to augment calcium intake during egg production (Nisbet 1997), particularly in acidified environments (Beintema et al. 1997; Brenninkmeijer et al. 1997; Mänd et al. 2000), the reverse relationship of snails exploiting an avian calcium source has not been recorded. This is likely because access by snails to avian calcium sources (i.e., eggs) is either limited during periods of nest attendance and incubation by adult birds, or because other avian calcium sources such as bones from dead chicks or eggshells ejected from the nest decompose or otherwise disappear from view.

Machias Seal Island (MSI; 44°30'N, 67°06'W) is a 9.5 ha treeless island in the Bay of Fundy, Canada, and is home to several nesting seabird species, including Arctic Tern, *Sterna paradisaea*, and Common Tern, *S. hirundo* (Diamond and Devlin 2003; Bond et al. 2007). In the summer of 2006, the tern colony was abandoned on 25 June, before any eggs hatched. Although the proximate cause likely was intense predation on tern nests by Herring Gulls, *Larus argentatus*, and Great Black-backed Gulls, *L. marinus* (AWD unpublished data), the ultimate cause is likely a decrease in available food supply, mainly 0-group Atlantic Herring, *Clupea harengus* (DFO 2005), which preceded several years of near reproductive failure for both tern species (Bond et al. 2007).

On 22 July 2006, eleven tern eggs that had not been taken by gulls were collected and it was noticed that many small land snails had attached themselves to the exterior of the tern eggs, causing surface aberrations (Figure 1). Through visual comparison with eggs not attended by snails, we wanted to determine if snails were "grazing" on the tern eggs. Snails have been observed on abandoned eggs at tern colonies in southern New England (I. C. T. Nisbet, personal communication, 2006), but their effects on the eggs' exterior was not examined.

Our objective was to use electron microscopy to compare visually the surface of eggshells attended by snails with sections of the same eggshell that were unattended and with shells of eggs that had no snails present at all.

Methods

Tern eggs were collected on 22 July 2006 from Machias Seal Island, Bay of Fundy, Canada. Eggs were taken from nests located in the central vegetated portion of the island, where Canada Bluejoint, *Calamagrostis canadensis*, dominates and is kept short by regular mowing. Areas immediately surrounding the tern nests were not mowed to avoid damage to the nests' contents. Once the eggs were collected, snails were removed from the eggs. Eggs were wrapped individually in cellophane, frozen at -18°C and transported to the University of New Brunswick, Fredericton, for analysis. Snails were similarly frozen in sterile polythene bags, and transported.

Eggshell samples were prepared and examined using a JEOL JSM 6400 scanning electron microscope with an operating voltage of 7 kV at the Microscopy and Microanalysis Facility at the University of New Brunswick. Small sections of shell were mounted on aluminium stubs using carbon tape and carbon paste to properly ground the specimens, and sputter-coated with approximately 50 nm of gold. Photographs were taken at either 90° (from directly above) or at 50° to the electron beam.

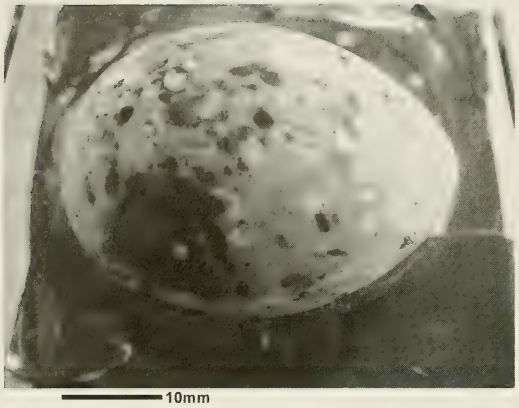

FIGURE 1. Abandoned Arctic Tern egg. Light circular marks on the shell's surface were the locations of snails.

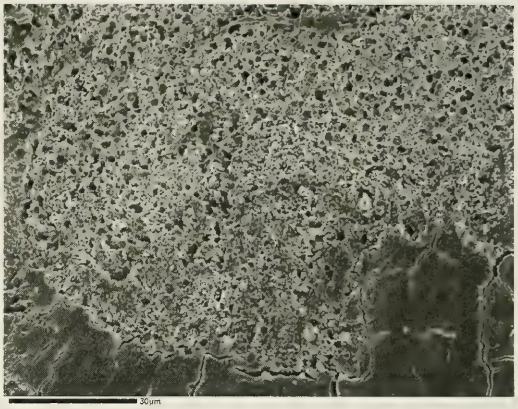

FIGURE 2. Grazed (top) and ungrazed areas (extreme bottom) of an Arctic Tern egg. Electron micrograph taken at 90° to electron beam.

Results and Discussion

Gastropods were identified at the New Brunswick Museum (Saint John, New Brunswick) as *Cionella lumbria* (Glossy Pillar; Stylommatophora: Cionellidae), a common terrestrial gastropod in the northeastern United States (Martin 2000), and immature or hatchling *Cepaea hortensis* (White-lip Gardensnail; Stylommatophora: Helicidae), which is common on several islands in the Bay of Fundy (D. McAlpine, New Brunswick Museum, St. John, personal communication, 2006).

Individual eggs had between 1 and 14 gastropods present (mean ± SD, 4.18 ± 3.79), with *Cepacaea hortensis* being more common (40 of 46 total gastropods found on ten eggs), and the remainder being *Cionella lumbria* (6 of 46, present on three eggs). Linear regression found no relationship between snail abundance and egg size (breadth or length).

Areas on the tern eggshell that were "grazed" by the snails had the outer surface layer removed, exposing the radially oriented crystals immediately beneath the tangentially-oriented crystals that form the shells' surface (Becking 1975; Figure 2), whereas ungrazed areas (Figure 3 top) appeared similar to shells collected in 2005 (Figure 3 bottom). An examination of the interface of the grazed and non-grazed areas with the photograph taken at 50° to the electron beam shows a "landscape" view, with the grazed areas lower than non-grazed areas (Figure 4), indicating the removal of the outer calcified layer of the eggshell by the snails. This outer crystalline layer varies in thickness from 1 to 10 mm in other bird species (Tyler 1964; Becking 1975), but it has not been examined previously in any of the Laridae.

It is unlikely that this method of calcium acquisition by snails would occur had the terns remained and incubated their nests through to hatching. Arctic Terns incubate their clutch of 1-3 eggs for approximately 21-23 days (Hatch 2002). Paquet (2001) found that incubating terns spent 41% of their daily time budget incubating the egg, and that for more than 80% of the time, at least one adult in the pair was tending the eggs. This implies that any colonization attempt by gastropods would be unsuccessful because the egg would be unattended and accessible by the gastropods very little of the time. If such colonization did occur, the contact with the adult during incubation would likely remove the gastropod from the eggshell.

It is likely that the large number of abandoned eggs drew our attention to what could be a common phenomenon at the microscopic level. Seabirds can alter soil chemistry drastically (Mizutani et al. 1991), and it is likely that eggshells ejected from nests and bones from dead adults and chicks provide a reliable source of calcium enrichment, which could be accessed by the snails.

Rainfall on Machias Seal Island was well above average in 2006, with 469 mm between 15 May and 18 August, compared with the mean (± S.E.) of 225.0 mm (± 29.2) over the previous 12 years (Bond et al. 2007), and this likely contributed to high productivity among the snails (Barrientos 2000; Tattersfield et al. 2001).

The gastropods' use of avian eggs as a calcium source is a reversal of the more typical relationship between birds and molluscs, as birds in acidified environments are often documented consuming molluscs to supplement production of calcium for their eggs (Beintema et al. 1997; Brenninkmeijer et al. 1997; Nisbet 1997; Mänd et al. 2000). It is our belief, though, that this behaviour in the snails is likely to be regular or frequent in occurrence, and that the snails are seeking new and abundant natural sources of calcium to promote shell growth, including abandoned eggs.

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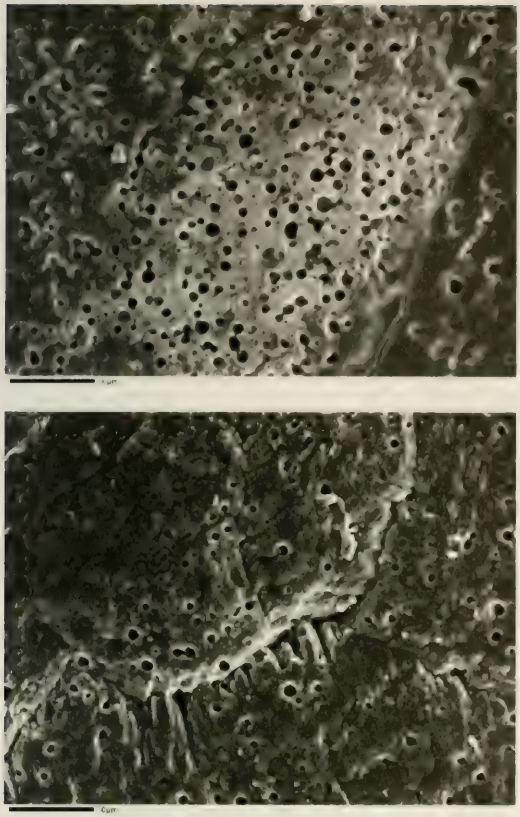

FIGURE 3. An ungrazed portion of the same shell as Figure 2 (above) and an Arctic Tern eggshell collected in 2005 with no snails observed (below). Electron micrographs taken at 90° to electron beam.

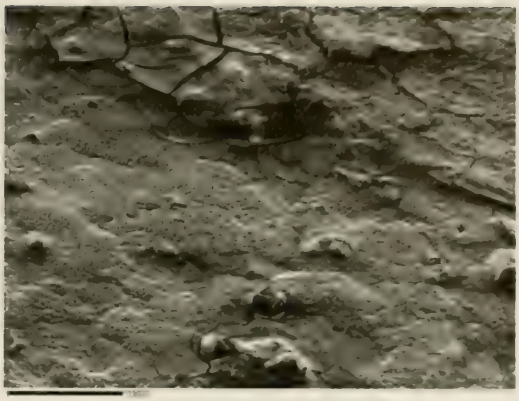

FIGURE 4. Arctic Tern eggshell showing grazed (bottom) and ungrazed (top) interface. Electron micrograph taken at 50° to electron beam to provide a "landscape" view.

R. Daley, R. Eldridge and R. Ross provided friendship and company on the island. D. F. McAlpine identified the snails, S. Belfry assisted with the SEM photography and S. Martin assisted in locating older references. K. C. Fraser, J. L. Lavers, A. J. Erskine and one anonymous reviewer provided helpful comments on previous drafts. The Atlantic Cooperative Wildlife Ecology Research Network funded this project. This is ACWERN publication number UNB-73.

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Fish-line Entanglement of Nesting Mourning Dove, *Zenaida macroura*

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Parker, Glenn H., and Chris G. Blomme. 2007. Fish-line entanglement of nesting Mourning Dove, *Zenaida macroura*. Canadian Field-Naturalist 121(4): 436-437.

We give a detailed account of monofilament entanglement in nesting material of a gravid female Mourning Dove (*Zenaida macroura*) which resulted in death. Such incidents substantiate the hazards of anthropogenic materials and the need to dispose of them with due diligence.

Key Words: *Zenaida macroura,* Mourning Dove, monofilament, fish line, avian anthropogenic hazards.

Mourning Doves (*Zenaida macroura*) nest annually in the town of Val Therese (46°39'N, 81°01'W), Sudbury District, Ontario. On 12 April 2005, an unusual flash of movement attracted my eye to the neighbour's 15-meter-tall Blue Spruce (*Picea pungens*). Upon more careful inspection, I noticed a Mourning Dove hanging unnaturally among the interior boughs of the spruce. An additional bird was present, presumed to be the other of a mated pair. Entering under the boughs, I noticed that the lifeless dove was hanging from a thread of monofilament fish line to which it had succumbed following an obvious struggle. One meter above the dangling bird, situated on a branch 1.75 meters from the trunk and 2.75 meters off the ground, was a fully-formed nest.

The hanging bird was a female Mourning Dove weighing 124 grams. Autopsy revealed that the bird was in a healthy state; the crop was full of wild seeds and normal amounts of adipose tissue were present throughout the body. A fully-developed egg with a near-calcified shell was present in the oviduct, indicating that egg laying would probably have occurred within a day. The nest was well-formed but empty, implying that nest construction had been completed and egg laying was about to commence.

The fish line was of ten-pound test and consisted of two separate lengths each entwined in the nesting material. The smaller piece measured 25 centimeters and the longer piece 2.5 meters. The longer piece was woven into the nest at mid-level, indicating that it had been incorporated during nest building rather than added later. The bird had become entangled with a portion of the longer line. The fish line ran between the sixth and seventh primary on the underside of the right wing, then looped over the dorsal surface of the humerus to the neck where it was looped completely around the neck. Subsequently, the line stretched to the left wing which was wrapped twice very close to the body, and then extended from the dorsum of the bird as a free end. The bird was dangling from the line anchored within the nest, with a single upwardly-extended wing and a severely down-turned head and neck directed into the pit of the extended wing. Strangulation as a result of the initial entanglement and panic response is inferred as the cause of death.

Various anthropogenic hazards have been reported to contribute to mortality in Mourning Doves, including decapitation from power lines, utility lines and TV towers while in flight (Stoddard and Norris 1967), window strikes (Terres 1980), and vehicle, train and aircraft strikes (Terres 1980). Monofilament fish line entanglement has been well documented in waterfowl, marine birds. (Manville 2005; King et al. 1979) and loons *Gavia* spp. (Sidor et al 2003) as well as noted in doves on previous occasions (Sadler 1993; Mirarchi and Baskett 1994). The tendency of certain species to incorporate foreign anthropogenic materials during nest building, including fine wires as noted in dove nests reported by Peck and James (1983), appears to predispose such species to higher risk levels. Specific details of incident reports appear to be lacking in much of the literature. This note serves to further document the use of discarded fish line (a non-natural nesting material) and its potential contribution to mortality in a common tree-nesting species.

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Bull Trout, *Salvelinus confluentus*, and North American Porcupine, *Erethizon dorsatum*, Interaction in the Mackenzie Mountains, Northwest Territories

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Cott, Peter A. and Neil J. Mochnacz. 2007. Bull Trout, *Salvelinus confluentus*, and North American Porcupine, *Erethizon dorsatum*, interaction in the Mackenzie Mountains, Northwest Territories. Canadian Field-Naturalist 121(4): 438-439.

Evidence of an interaction between a Bull Trout (*Salvelinus confluentus*) and a North American Porcupine (*Erethizon dorsatum*), was observed during a fisheries survey in the Mackenzie Mountains, Northwest Territories. A male Bull Trout with porcupine quills imbedded in its mouth was collected. It is speculated that this occurred when the trout was aggressively defending its territory from a perceived threat – a swimming porcupine. This is the first documented account of an interaction between a fish and a porcupine.

Key Words: Bull Trout, *Salvelinus confluentus*, North American Porcupine, *Erethizon dorsatum*, prey, interaction, diet, Northwest Territories, Mackenzie Mountains, Mackenzie Valley.

We report an interaction between a Bull Trout (*Salvelinus confluentus*) and a North American Porcupine (*Erethizon dorsatum*), two animals that, due to different life history requirements, would rarely be in contact.

The Bull Trout is a native salmonid (genus *Salvelinus*) occurring in streams, rivers and lakes across western North America. The species' range extends from northern California to the central Northwest Territories [NWT] (Haas and McPhail 1991; Reist et al. 2002; Mochnacz et al. 2004; Stewart et al. 2007a). Bull Trout are a top level predator consuming a variety of prey items ranging from insects to small mammals (Stewart et al. 2007b). North American Porcupines are large rodents, weighing up to 14 kg and are widely distributed from the Arctic Ocean to northern Mexico (Roze 1989). Porcupines occupy a variety of habitat types and are considered generalist herbivores (Roze 1989). Their dorsal surface is covered with modified guard hairs in the form of barbed quills, which serve as protection against predators. Predators include the Wolf (*Canis lupus*), Coyote (*Canis latrans*), Wolverine (*Gulo gulo*), Fisher (*Martes pennanti*), Cougar (*Puma concolor*), Canada Lynx (*Lynx canadensis*), Bobcat (*Lynx rufus*), and Great Horned Owl (*Bubo virginianus*) (Roze 1989). When a porcupine is attacked, the quills are driven into the assailant and released from the porcupine's skin, allowing the porcupine opportunity to escape (Roze 2002).

On 1 September 2007, during a field survey to delineate the distribution and assess habitat use of Bull Trout in the Mackenzie Mountains, NWT, two male Bull Trout were angled from a pool in an unnamed tributary of the Redstone River (63°39'001"N, 125° 23'414"W). The larger fish (fork length 583 mm, 2022 g) had four Porcupine quills embedded in its mouth. The quills were in the thin skin covering the upper mandible (Figure 1), with no quills in the esophagus or stomach, which suggested that the Bull Trout had bitten a porcupine, rather than scavenged off a carcass. Only fish remains were found in the trout's stomach. The size and colouration of the quills were consistent with those from the side of a porcu-

FIGURE 1. A Bull Trout (*Salvelinus confluentus*) collected from an unnamed stream in the Mackenzie Mountains, Northwest Territories, impaled by the quills of a North American Porcupine (*Erethizon dorsatum*).

pines' tail, suggesting a defensive interaction (U. Roze, Queens College, Flushing, New York, personal communication 2007). For a Bull Trout to encounter a porcupine, the latter would either have to be wading or swimming across a stream, or less likely, floating dead down a stream. Porcupines are known to swim or otherwise traverse watercourses to access different parts of their range (Murie 1926; Roze 1989). When a porcupine swims, the majority of the body is below water, with the head and some of the back and tail visible above the surface, much like a Beaver (*Castor canadensis*) (U. Roze, personal communication 2007). Bull Trout often live in environments that have sparse food resources and are, therefore, opportunistic predators (Stewart et al. 2007b). However, given a porcupine's size it is unlikely that it was a potential food source. A more plausible explanation is that the Bull Trout was defending its territory against the porcupine which the fish interpreted as a threat. Bull Trout are very aggressive, particularly during spawning, and have attacked SCUBA divers during *in situ* spawning surveys (J. Stewart, Fisheries and Oceans Canada, Winnipeg, personal communication, 2007). The time frame of the survey and temperature observed (6.0°C) are both within the preferred ranges for spawning Bull Trout in the NWT (Mochnacz et al. 2004) and further south (Baxter and McPhail 1996).

This is the first record of a Bull Trout, or perhaps any fish, attacking a North American Porcupine. Although an interaction between these two species is certainly a rare event, the fact that it occurred is evidence of the aggressive behavior of Bull Trout, and the unusual and unforeseen linkages that can occur within a given ecosystem.

Acknowledgments

We thank Jim Reist and Stephanie Backhouse, Fisheries and Oceans Canada, Winnipeg, Manitoba; Murray Somers, Fisheries and Oceans Canada, Yellowknife, Northwest Territories; Jesse Pierce and Guy Thibault, Sahtu Helicopters, Norman Wells, NWT; Richard Popko, Department of Environment and Natural Resources, Norman Wells, NWT. Uldis Roze, Queens College, Flushing, New York, and John Babaluk, Fisheries and Oceans, Winnipeg, Canada, who reviewed earlier drafts; and two anonymous reviewers for helpful, constructive critiques of this manuscript.

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Book Reviews

Book Review Editor's Note: We are continuing to use the current currency codes. Thus Canadian dollars are CAD, United States dollars are USD, Euros are EUR, China Yuan Renminbi are CNY, Australian dollars a AUD and so on. You will find these are the codes now used by financial institutions and internet currency converters. I will include an updated note for the next few issues as a reminder.

ZOOLOGY

The Ecology & Behavior of Amphibians

By Kentwood D. Wells. 2007. University of Chicago Press, 1427 East 60th Street, Chicago, Ilinois 60637. 1148 pages. 75.00 USD.

This massive volume synthesizes knowledge gained through researcher Wells' extensive field experience and total immersion in the literature focussed on habitats and habits of a generous sampling from the approximately 6000 species of amphibians now recognized in the world. Its extended gestation time began with conception and partial drafts in the early 1980s. The period since has been one of ever-increasing research and publication by a growing number of researchers resulting in exponential additions to the number of species recognized and, especially, the volume of information on them. But simultaneously, it has been a time of realization of the fragility of the world's amphibian fauna and the decline, sometimes the extinction, of many species in many parts of the world ascribed to a variety of causes. Wells has been long-recognized as one of the most productive and original researchers on amphibians of this period.

His book has 16 chapters, the first on phylogeny, classification, and morphological evolution, followed by ones on water relations, temperature relations, respiration, metabolism and energetics, movements and orientation, anuran vocal communication, mating systems and sexual selection in anurans, communication and social behavior of urodeles and caecilians, the natural history of amphibian reproduction, parental care, ecology and behavior of amphibian larvae, complex life cycles and ecology of amphibian metamorphosis, amphibians and their predators, the ecology of amphibian communities, and, finally, the conservation of amphibians. The reference section well reflects the vastness of the information in the volume itself – the two-column format occupies 238 pages, the length of many books. Included are many, but by no means a comprehensive selection of relevant papers by Canadian herpetologists. Finally, a 64-page index concludes the text. It is unfortunate that the initial chapter summarizing classification was completed before Frost and his colleagues (2006 American Museum of Natural History Bulletin 297) published their extensive reassessment of amphibia relationships which proposed many changes in nomenclature that could not be evaluated for possible inclusion here. This is not a serious flaw as the book's overall emphasis is not on systematics.

Wells has deftly managed both a detailed and a readable reference and primer for study of amphibians in nature. Its price and mass (approximately 11×8.5×2.2 inches or 286×220×60 mm) will doubtless keep it from many a naturalist's library shelves, except for the few primarily focussed on amphibians who have ample disposable income (perhaps not a common combination), but it is a must for every university biology and federal and provincial government environment department and should be read by all biology students and conservation-charged public servants. Graduate students focussed on amphibians or vanishing habitats in particular, will find this a treasure of the research to date, and a gold mine of background information to inspire future research projects.

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The Amphibians and Reptiles of New York State: Identification, Natural History, and Conservation

By James P. Gibbs, Alvin R. Breisch, Peter K. Ducey, Glenn Johnson, John L. Behler, and Richard C. Bothner. 2007. Oxford University Press, 198 Madison Avenue, New York, New York 10016. 422 pages. 34.50 USD.

Lack of an authoritative field guide to the herpetology of the state of New York has been a glaring vacuum in texts on the northeastern United States throughout the last century. This, despite its relatively large size for a northeastern state (49 108 square miles or 127 189 km^2), and being the home of many exceptionally prominent herpetologists over the last century. The state had been among the earliest to be given a comprehensive scientific treatment when James DeKay (for whom the snake *Storeria dekayi* is named)

included amphibians and reptiles in his *Zoology of New York* in 1842. Almost 100 years later (in 1941) it received the most through state monograph on a single group, the *Salamanders of New York* by Sherman Bishop, Rochester, New York. Bishop followed this with a handbook to all North American salamanders. Others included, in the first half of the 1900s, Raymond Ditmars, New York, who wrote immensely popular and influential books on reptiles of North America and of the world and, Albert and Anna Wright, Ithaca, who used local studies to produce the first comprehensive data on the life histories of eastern North American frogs and toads then went on to produce North American handbooks to frogs and toads in 1933, revised in 1942 and 1949, and to snakes in 1957.

The six authors who finally have filled the need for a field guide are also New York state residents, scattered among universities, conservation departments and organizations: Gibbs at the State University of New York College of Environmental Science, Syracuse; Breisch at the New York State Department of Environmental Conservation, Albany, Ducey at the State University of New York at Cortland, Johnson at the State University of New York at Potsdam, and Bothner at St. Bonaventure University, Olean. The late John L. Behler (1933-2006) was with the Wildlife Conservation Society, Bronx. The distributional data are from the Amphibians and Reptile Atlas Project of the New York Department of Environmental Conservation which compiled 59 000 reports submitted by 1800 volunteers. The atlas also included 28 000 pre-1990 records from museums, field notes, graduate theses, and published literature.

The text covers 69 native species (18 salamanders, 14 frogs and toads, 17 turtles, 3 lizards and 17 snakes), and includes 65 distribution maps (ranges shaded, but without spot localities) and 72 colour plates (each with one to four superior, sharp photographs of pattern and life stage variants contributed by over 30 photographers). Each species account is headed with English and Scientific names followed by sections on Quick Identification, Description, Habitat, Natural History, Status and Distribution, and Other Intriguing Facts. Statements are referenced to a 39-page Literature Cited section. Many leading Canadian herpetologists are cited, among them classical studies by J. P. Bogart on ambystomid salamanders and R. J. Brooks on Snapping and Wood turtles (both at University of Guelph), M. Berrill on pesticide effects and declines (Trent University), J. Gilhen on Nova Scotia species (Nova Scotia Museum), D. M. Green on hybridization in toads (McGill University), P. J. Weatherhead, K. A. Prior, and G. Blouin-Demers on Rat Snakes (Carleton University, Environment Canada. and Ottawa University, respectively).

But the text is not just species accounts. A brief introduction summarizes the history of state herpetology and stresses the conservation theme found throughout the book. It is followed by a discussion of the state herpetofauna with a table giving, for each species, its New York Natural Heritage Program State Rank, NatureServe Global Rank, and (where applicable) its New York State and Federal Listings, exotic species sometimes reported (alligators in the sewers of New York City and beyond) and similarities and differences between amphibians and reptiles. The is a chapter on New York's environment as habitat for amphibians and reptiles with maps of ecological zones, of major lakes and rivers, of counties and major cities, and "land cover". The ecological zones are described with representative habitat photos and a table of all species and habitat types they occur in. Final chapters are Threats outlining the effects of historic overexploitation (particularly commercial harvest) and habitat loss over time, acid rain, contaminants, disease and deformities. Following chapters discuss legal protection, habitat conservation guidelines, conservation case studies, finding and studying amphibians and reptiles, folklore, and epilogue. Appendices cover the "Herp Atlas" Survey Card, and Resources (organizations and identification and general reference). A Glossary covers terms from amplexus to wetland, followed by Literature Cited and a 20-page index.

Eastern Canadian naturalists will find this book a must for their bookshelves as an excellent reference not just to the species included (species that occur in eastern Canada are also in New York) but also for conservation approaches and philosophy. It lacks only a section on care of captives, and that, I suspect, is not an oversight but deliberate, making a strong statement by its omission.

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Extreme Birds

By D. Couzens. 2008. Firefly Books Ltd., 66 Leek Crescent, Richmond Hill ON L4B 1H1. 281 pages. 45 CAD Cloth.

When *Extreme Birds* arrived in the mail, it caught my attention with its dramatic, somewhat comical, cover photograph of a Shoebill. I started to nose through, looking first at the remarkable photographs, and wondering who might review this book. Then the chapter titles made me take a second look and I was hooked! I expected widest wingspan, smallest bird, longest bill and so on, but heaviest testes, biggest belly and smelliest bird took me by surprise. In the author's view the malodorous claimant is the Crested Auklet. These cute beasts are said to emit a potent, tangerine-like stink that carries for miles. I am afraid I missed that pleasure last year when we sailed by their colonies; there is an advantage or disadvantage to having a poor sense of smell.

This book not only covers the record individual characteristics, like largest and smallest, but includes three other categories. Extreme Ability covers such performance heights as fastest swimmer, best flock coordination and best mimic. Extreme behaviour describes the strangest incubation, the loveliest display and the best drummer. Finally Extreme families documents the limits of courtship, promiscuity and breeding.

Many of the author's choices will not surprise the ardent birder. The widest wingspan belongs to the Wandering Albatross. The biggest eyes [5 cm] are in the head of an Ostrich and the smallest bird is a Bee Hummingbird [5.7 cm]. So the little hummer could almost squeeze into an ostrich eye. Although the choices are obvious, the author tucks in many fascinating details. The ostrich eye is as big as an eye can be, or diffraction would cause problems. It would take 3000 Bee Humming bird eggs to equal the weight of one ostrich.

I did not realize there was a poisonous bird, the Hooded Pitohui of New Guinea. Apparently this bird absorbs batrachotoxin alkaloids from the Choresine beetles it eats. This toxin is also found in some poison-dart frogs and believed to come from their diet too.

Under the title "Classiest Colours" Couzens gives an excellent discussion of the feather colour of a turaco. This genus is the only one to make green pigment [other "green" birds use refracted light to give the impression of green] and the author covers the process in simple and elegant language.

For the whitest bird he chooses an Ivory Gull, not what came to my mind. I would say several egrets are good contenders, but my choice would be the Snow Petrel. Not only are these little birds bright white, but they have a beautiful sheen that gives them a special glow. Perhaps they did not "win" this category as the Great Egret is cited for the best grooming aids [its powder down and pectinated, comb toe] while the Snow Petrel gets the "Most relaxed attitude to breeding." However the Barn Swallow gets two citations as "Sexiest tail" and Canniest false alarm."

The author often chooses one species, but the same remarks can be made of others in the genus. The longest legs are not confined to the Lesser Flamingo but are characteristic of all flamingos. Similarly at least the Variable Pitohui and the Brown Pitohui [there are six in the genus] are poisonous as well as the Hooded Pitohui. Indeed Blue-capped Ifritas carry the same toxin.

The photos, one for each species, come from professional stock companies. Therefore they are superb. It is futile to try and pick the best ones, but those that caught my attention were Lesser Spotted Eagle [so majestic], Clarke's Nutcracker [so homely], Western Capercaillie [so haughty] and the Barn Owl [such a beautiful bird]. The photo of the Red-crowned Crane is so artistic it could be a Japanese woodcut by Hokusai or Hiroshige.

I usually read bird books to learn something. While this is a pleasurable act, the primary focus is not amusement, but information. I read this book because it is fun. Even when I knew the facts, such as the Emperor Penguin's unbelievable fast, I enjoyed this author's version of the tale. It was even better when I was learning something new, like the Great Crested Grebe's passion for eating its own feathers. So if you want to know the biggest, the fastest, the smallest, best nest builders, weirdest matings and who dives the deepest or flies the highest, then this is the book for you. Even non-birder trivia fans will get great enjoyment.

Oh yes, and the heaviest testes [8% of its body mass and heavier than its brain] record is held by the Alpine Accentor. For good reason too, but you really should read the book to find out why! And then there is the bird that f*rts to catch its food – but that is another story.

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Cranes: A Natural History of a Bird in Crisis

By Janice M. Hughes. 2008. Firefly Books Ltd. 66 Leek Crescent, Richmond Hill, Ontario L4B 1H1 Canada. 256 pages. 45 CAD Cloth.

Firefly Books produces well-illustrated nature books featuring larger format, glossy paper, and generally readable text. Cranes are exciting birds, and they have captured mankind's imagination for millennia, so they make good subjects for a book of this character. It is written by Janice Hughes, an Associate Professor at Lakehead University.

With a title like *Cranes* one might expect the subtitle to refer to a "Family in Crisis" but in fact the "Bird" referred to is the Whooping Crane, and despite the emphasis on the dust jacket on cranes as a group, two-thirds of the text is devoted to the history of this one species. Chapters one and six cover the family as a whole, the first outlining their natural history, and the second profiles of the 15 species. Perhaps appropriately, the natural history section includes extensive coverage of the species' relationship to man, starting with a section on mythology, folklore and cultural importance, and concluding with demographics and threats, and crane conservation. In chapter 6 each species is assigned two pages in a smaller type-face, including a range map and a rather small [~3×5 inch] picture.

Chapters 2 through 5 chronicle, first the decline of the Whooping Crane, followed by accounts of its recovery, discussing in turn the bird's population and migration, and concluding with a summing-up. Because the threats to cranes are mentioned in a number of sections, there tends to be some repetition of material. Two appendices provide the World Conservation Union ratings of crane status, and wild Whooping Crane peak winter counts from 1938-1971.

I was rather disappointed by the book, mainly because the Whooping Crane sections are so dominant in it that I had a feeling the rest of the species were almost an after-thought. The family is a rather homogeneous one, so treating the natural history of the birds as a group is reasonable, but the two-page summaries are just that – summaries – and the illustrations in them are inadequate given the scope and size of the book. In fact, the pictures in general are not up to the standard one expects from a book of this type. Many of the ones in my copy are a little off, lacking sharpness, and some are no more than cropped versions of pictures that appear earlier.

The text is rather uneven. Some parts are rather plodding. The author lapses periodically into jargon and then, for those who might not understand, pops in a brief explanation. Why use the term in the first place? At its best, however, it is well-written, even eloquent, especially in sections discussing the plight of cranes. The Whooping Crane history is given in considerable detail, even to the extent of outlining the events leading to the formation of the Audubon movement.

Those seeking a comprehensive treatment of the world's cranes will find this book wanting. If you are interested in the fascinating account of the collapse and gradual recovery of the Whooping Crane in North America, coupled with an overview of cranes generally, then this could be a good book to acquire.

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Marine Mammals of the Pacific Northwest: A Concise and Comprehensive Waterproof Guide

By P. A. Folkens. 2001. Harbour Publishing, P.O. Box 219, Madeira Park, British Columbia V0N 2H0. 8 pages. 9.95 CAD – (synthetic film).

The increasing development of the whale-watching industry has resulted in the demand for, and creation of, books and identification guides for sea mammals, seabirds and the marine ecosystem. In this regard, and looking back on a history of whale-watching for over 90 years, the coast of British Columbia has received most of the publication activity in Canada.

Despite its catchy title, this guide by Pieter Arend Folkens is more a leaflet of a guide. It consists of three text pages and five pages of drawings and photos full of information for the whale watcher in the field. Although the leaflet is printed on "waterproof, UV resistant synthetic film made from a 100% recyclable, environmentally inert material containing no forest products (similar to milk jugs)", the user might actually have difficulties using it on an offshore whale watching trip during periods of stronger wind or higher waves; the light leaflet could easily fly away and the small print is hard to read when on a rolling boat. However, the compressed text gives a nice summary and overview on 31 sea mammal species in the area; it even mentions Steller's Sea Cow, which was hunted to extinction by 1768. In addition, major whale watching locations in British Columbia and Alaska are named, but none are reported really for Oregon and Washington (as the title would imply).

Most of the eight pages of the field guide are devoted to drawings and to fine pictures from the author and several others. The reader might find the distinction between *Mysticetes* (Baleen Whales), *Odontocetes* (Toothed Whales) and Small Cetaceans a little unclear from the arrangements of the drawings. Very helpful and informative is the page about "Common visible behaviours and terms" allowing to link sea mammal sightings to a classified set of behaviour types. Helpful also is that images of fluke displays are presented for species that are known to show such a behaviour. Even the body sizes of newborn sea mammals are given. All measurements are made in SI units, and the conversion factor for feet is provided.

Of interest to the general audience might be the section "Marine Mammal Watching Guidelines", also presented on the web http://www.fakr.noaa.gov/protectedresources/mmviewingguide.html (Note that the old URL www.nmfs.gov/prot_res.html and given in the guide was updated). In addition, contact addresses and a web address (revised to http://www.fakr.noaa.gov/protectedresources/strandings.htm) are given for sightings of stranded sea mammals (Department of Fisheries and Oceans Canada, 800 4654336; or the Whale Reporting & Stranding Line 800 665 5939).

As found in many other field guides, the text suggests some field marks and details for species identification and separation that normal whale watchers might not be able to apply, or which are not really realistic. For instance, Sei Whales are supposed to be differentiated from Fin Whales by a fin angle of over 45 degrees; male Beaked Whales (genus *Mesoplodon*) ideally can be identified by the location of teeth and jaw line (which is for most of the time covered by the ocean); phocids (true seals) differ from otariids (Sea Lions and Fur Seals) by their hair and small nails on their foreflippers. Overall, features like these might be very hard to recognize for the untrained as well as for the trained observer, particularly when observations are done for moving animals, from a shaky boat far away and with binoculars. Rather than focussing on classical small-scale features, outlining the use of proportions and shapes could be more useful for telling species apart. Counterproductive for a field guide might be the point that Beaked Whales, the species group that lacks most knowledge on distribution and where whale watchers could indeed contribute greatly to science, are described as the "most difficult whales to identify correctly"; no further help or details are given for the interested whale watcher. For my taste, the "Habitat and Symbol Keys" that are supposed "to

narrow possibilities in a particular area" and link sea mammals with "habitat" are not really helpful since many whales migrate across habitats anyway and since the regular observer has no real way to tell "temperate" habitats apart from "cool temperate" ones. The meaning of the orange W habitat class presented for the False Killer Whale will likely remain a mystery to the reader because its meaning is nowhere explained in the guide. For pinnipeds, their "calls" and the mentioning of rookeries could have been helpful.

Overall, it appears that this "guide" is an excerpt of a better and larger guide book from the same author. It is useable in the field, but does not replace the real and classical guide books.

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Reptiles and Amphibians of Canada

By Chris Fisher, Amanda Joynt, and Ronald J. Brooks. 2007. Lone Pine Publishing, 206, 10426 – 81 Avenue, Edmonton, Alberta T6E 1X5. 208 pages. 18.50 CAD.

It has been 24 years since the first comprehensive one-volume guide to all Canadian amphibians and reptiles known at the time appeared (Cook 1984) and that is now badly out-of-date and, fortunately, out-of-print. There have been new guides to several provinces since and a highly popularized superficial attempt for the entire country by Bumstead (2003).

For this new effort, only the third author, the legendary Ron Brooks of the University of Guelph will be very familiar to most Canadian herpetologists. Brooks has long been a CITES committee member and crusader and has made an extensive ecological contribution with a legion of graduate students conducting studies at Algonquin Park and selected central and southern Ontario sites. These have produced new insights into the lives of turtles and aquatic frogs in eastern Canada and one especially endangered snake (the Blue Racer). The other two authors have BScs from the University of Alberta. Chris Fisher is a writer of wildlife articles and field guides and lecturer on wildlife. Amanda Joynt, an ecologist from the Okanagan Valley, was a technician with Parks Canada and Canadian Wildlife Service, followed by writing full time for Lone Pine publishing, ecological surveys including rare plants in South Dakota, and direction (2004-2006) of Children in Wilderness Malawi, southern Africa. She now is a biologist for Fisheries and Oceans Canada in Inuvik, Northwest Territories.

The book is traditionally organized and opens with the mandatory acknowledgements, including one to Ron Brooks, odd in that he is also a coauthor. There is a very useful "Species at a glance" which gives a miniature reproduction of the text illustration, species by species, together with size, and account page number. The 12-page Introduction briefly highlights the antiquity of the groups and their characteristics. A map plots the location of selected national and provincial parks in Canada. This is followed by a summation of major habitats from the temperate west coast to the Maritimes, a discussion titled "the good, the bad and the misconceptions", and another on the general harmlessness of most species as well as the negative aspects of keeping native species (not the least of which is that in most provinces, is illegal to keep many species except under permit from resource departments). A few words on conservation are followed by the headings used in the species accounts. The latter are the bulk of the book (150 pages) and cover both native and introduced species: 11 freshwater or terrestrial turtles and 4 marine ones, 7 lizards, 26 snakes, 21 salamanders, and 25 frogs (including toads and treefrogs, etc.). Three of the turtles and are introduced or likely so, and two of these probably no longer occur, one lizard is introduced and one apparently extirpated, and one snake (Timber Rattlesnake) is extirpated.

Each species account is dominated by an enlarged colour drawing of an adult, and these vary from very good to embarrassingly bad. Some of the snakes, turtles and frogs are among the excellent, some salamanders and virtually all the lizards are poor, the latter particularly washed-out, among other faults. The Common Garter Snake represented seems to be a particularly odd colour pattern (a Pacific region variant?) that will be unrecognized in most of the country. The Plains Garter Snake is very pale, typical of the southern and eastern portions of the range mostly beyond Canada, while the "Eastern Ribbon Snake" on the next page matches the majority of Canadian specimens of plains species. In Canada, Ribbon Snakes rarely have an orange dorsal stripe (I know of only one report) like the one pictured; the lateral stripe is usually prominently bordered below by chocolate, and overall it is more slender. Among other snakes particularly poorly done are the Red-bellied, Brown, and Green snakes. The species accounts themselves lead with English and scientific names followed by a casual informal introduction, then a paragraph ID (identification), and one or two lines on Length, Distribution (with a tiny map of Canadian range), Habitat, Activity Patterns, Reproduction, Food, Similar Species, French Name, and a Did You Know sidebar, the latter focussed on some additional fact regarded as particularly remarkable. Each native and existing species is given two facing pages. The marine turtles (designated "vagrant species") fare even less well, with only a half page each, and the introduced or extirpated ones only somewhat better at one page each. The format of necessity means that only the briefest information can be given for each. Sometimes these have little Canadian relevance. An example is the statement

that the Small-mouthed Salamander "often" shares breeding ponds with Spotted Salamanders. Presumably this applies to United States populations as in Canada the Small-mouthed Salamander has been recorded only on Pelee Island where Spotted Salamanders apparently do not occur. But omitted from the Small-mouthed Salamander account is mention of its extensive hybridization with Blue-spotted Salamanders on Pelee Island although elsewhere the hybridization of Blue-spotted with Jefferson salamanders is recognized.

On the positive side, this book does have all the species we know in Canada to date with distributions, many interesting highlights, and very colourful pictures. These will be found useful by some casually interested uncritical naturalists. However, it is no substitute for the many carefully researched and more comprehensive, within their more limited areas covered, provincial guides available for amphibians and reptiles.

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Bumstead, Pat E. 2003. Canadian skin and scales: A complete encyclopedia of Canadian amphibians and reptiles. Simply Wild Publications Inc., Calgary. Alberta. 161 pages.

Cook, F. R. 1984. Introduction to Canadian amphibians and reptiles. National Museum of Natural Sciences, National Museums of Canada. 200 pages.

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Guides and Reference to the (1) Snakes, (2) Crocodilians, Turtles, and Lizards (3) Amphibians, of Eastern and Central North America (North of Mexico)

By R. C. Bartlett and Patricia P. Bartlett. 2005 (1), 2006(2&3). University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611. 342 (1), 316 (2), 283 (3) pages. 29.95 USD each.

The Bartlett team has produced a number of earlier books: *A Field Guide to Florida Reptiles*, *Reptiles and Amphibians of the Amazon: An Ecotourists Guide* (2003), and *Florida Snakes: A Guide to Their Identification and Habits* (2003). R. D. Bartlett, veteran herpetoculturist/herpetologist, founder of the Reptilian Breeding and Research Institute, boasts over 40 years writing and photographing, including more than 500 articles in magazines such as *The Tropical Fish Hobbyist*, *Reptiles*, and *Reptile and Amphibian*. Patricia Bartlett, former director of the Fort Myers Historical Museum, is an editor and writer who, in addition to coauthoring 12 books with R.D.B., also wrote *A Dictionary of Sharks*.

In these present volumes, the Bartletts have broadened their horizons and compiled a herpetofauna reference in three volumes which cover the entire eastern and central United States and adjacent Canada from the Atlantic to the tier of mid-western states from North Dakota to Texas. However, their southern bias persists. Species which range far north of the U.S. border have only the southern portion of their Canadian range shown on the generally crude distribution maps which only casually outline Canada, with the northern potions of the Canadian-based range are often cut off. No Canadian-based authors are included in the references, despite the many that have studied species included, some even from U.S. populations as well as Canadian material.

Each book has a brief Species List, a Preface and Introduction to the group(s) included. The bulk of the texts are accounts arranged by family and within these by related groups of species, and then individual species accounts. The later includes English and Scientific name followed by sections on Toxicity/Disposition (Snakes), Abundance/Range, Habitat, Size, Identifying features, Voice (in crocodilians and frogs), and Similar Species, Comments, and Additional Subspecies. There is a rather eclectic selection here sometimes of subspecies far to the west of the limits set for the book. There is a distribution map (see comment above), and one or more colour photographs for each species (regrettably without localities or date), but usually of spectacular quality, and it here that the book shines, and wins a place on many shelves.

But why, aside from this, would any Canadian naturalist want these books on their shelf? They do include all the species in eastern Canada, as all of these range north into this country from the United States. These accounts are of reference value for depictions of appearance (many species pictured are different from the Canadian variants) and natural history (contrast from more southern habitats) of these species in areas adjacent to Canada and beyond.

Attractive as it is, it is primarily an add-on for Canadian naturalists unless they are travelling south, and for practical purposes there are now many Canadian and adjacent state guides to reptiles and amphibians combined in single volumes that will be more useful references for identifying our herpetofauna.

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BOTANY

Ginkgo in China

By Cao Fuliang. 2007. China Forestry Publishing House, Number 7, Liuhai Hutong, Denei Street, Xicheng District, Beijing, China. 300 pages. 98 CNY.

Ginkgo is a genus of highly unique plants with one extant species, *Ginkgo biloba*, which is a long-lived, stress-tolerant, disease-, pest-, and fire-resistant dioecious tree, referred to as a living fossil by Charles Darwin in 1859. The only surviving member of its family, Ginkgo leaf was first mentioned in Lan Mao's book *Pharmaceutical Natural History of Southern Yunnan* (1436) in the Ming dynasty of China. Engelbert Kaempfer (1651-1716), a German botanist, firstly gave a scientific description of this species in his book *Amoenitatum exoticarum* (1712), and formly gave it its name according to a phonetic pronunciation of a Chinese or Japanese word.

It was reported that fossils recognizably related to modern *Ginkgo biloba* date back to the Permian, some 270 million years ago. The genus diversified and spread throughout Laurasia during the middle Jurassic and Cretaceous, but became much rarer thereafter. At the end of the Pliocene, Ginkgo fossils disappeared from the fossil record everywhere apart from a small area of central China where the modern species survived. Chinese people, especially the monks in history formally, have long cultivated Ginkgo, thereby contributing to its survival as a species. All the present Ginkgo trees originated from China and were introduced into Europe in the 1700s, and then spread to other continents.

Ginkgo not only has scientific value in terms of research on its evolution and genetic tenacity, but also its medicinal and ornamental applications. Ginkgo has been used in medicinal botanicals in China for more than 2000 years. Nowadays, more and more medicinal functions of its leaves and seeds are being extensively revealed by scientists all over the world, with a focus on the standardized *Ginkgo biloba* extract (GBE) being prepared from the dried green leaves. At present, Ginkgo has become one of the most common trees along the sidewalks in many cities of the world due to its urban tolerant traits and the beautiful shape and colour.

China is the hometown of modern Ginkgo trees. The small-sized natural Ginkgo populations were extensively distributed over different geographical areas of China. The cultivation area of Ginkgo covers wider regions. The germplasm resource of Ginkgo is abundant. Ancient Chinese carried out preliminarily studies or observations on the trees. However, afterwards, there were not too many new studies in China due to the unstable or abnormal social and political situation. Since the 1980s, Chinese scientists have carried out a series of comprehensive studies on the trees. The book *Ginkgo in China* is a systematic summation of these studies. As well, the book collected and analysed other abundant information on the Ginkgo at home and abroad.

The book covers almost every aspect of the Ginkgo, such as its origin, evolution and taxonomy, history of cultivation and utilization, natural populations and cultivation areas, biological and ecological characteristics, cultivation techniques, exploitation and use of Ginkgo resources, genetics and breeding, and so on. Chapter one, is an outline of the Ginkgo's name, and its economic, ecological, social, cultural, scientific values, developmental status, and prospects; Chapter two covers the origin, evolution and taxonomy of the Ginkgo; Chapter three, the history of cultivation and utilization of the Ginkgo at home and abroad; Chapter four, the natural populations and cultivation regions of the Ginkgo; Chapter five: the biological characteristics of ginkgo; Chapter six, the cultivation techniques of ginkgo; Chapter seven, the comprehensive exploitation and utilization of Ginkgo resources; Chapter eight, the germplasm and breeding of the Ginkgo; Chapter nine, reputed varieties, strains or individuals of Ginkgo in China; Chapter 10, key areas of Ginkgo production; and Chapter 11, the development of the culture of the Ginkgo.

The book is well written with few errors, and can be easily understood by non-scientists. As a comprehensive book, it would be suitable for anyone who is engaged in various areas of research or application in relation to ginkgo. Hopefully, it would become a valuable reference for them.

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Comprehensive Monograph of Contemporary Medicinal Plants (Volumes I-IV)

By Zhao Zhongzhen, Xiao Peigen. World Book Publishing House, Number 137, Chaonei Street, Beijing, China. 2008. 4 volumes: total 2180 pages. 368 CNY Cloth.

In a broader sense, the medicinal plants referred to are not only the so-called traditional medicinal plants used for prevention and treatment of human diseases, but also the plant resources used as nutrients, hobby materials, spices, coloring additives, pesticides and veterinary drugs and so on. The whole or parts of the medicinal plants can be used directly in treatment or as raw material in the pharmaceutical industry.

China is one of the countries with abundant resources of medicinal plants, and with the long history of use and cultivation. The discovery of medicinal plants was

the result of accumulation of experience and knowledge in the long-term production and life in ancient times. In China, literary records on medicinal plants might be traced to the Spring and Autumn Era (770 BC~221BC) or much earlier. Till the Ming Dynasty, the world wide famous comprehensive medicinal book *Compendium of Materia Medica* (Li Shizhen 1578), contained more than 1200 species of the medicinal plants.

Generally speaking, Chinese traditional medicine as a cultural treasure of China, together with Western medicine, plays an important role in human health care, and is the commonwealth of mankind. However, not all records in the traditional medicinal literatures were correct, and some of them were proved to be wrong or inaccurate with long-term clinical practices or scientific tests. Furthermore, some new pharmacological effects of these medicinal plants have been revealed, and some new medicinal plants have been gradually added to our knowledge. Therefore, the science of medicinal plants as an ancient and developing science needs systematic testing of the records in the traditional medicinal literature, and also needs a continual infusion of new knowledge or scientific findings. Actually modern medicine, or Western medicine, as a whole, has persistently absorbed a great deal of valuable experience and knowledge accumulated in the course of long-term clinical application and scientific research. However, the science of medicinal plants itself has been in the shade, and not summed up the progress of time.

The *Comprehensive Monograph of Contemporary Medicinal Plants* is divided into three parts and four volumes. The Chinese and English versions were published successively. The book collected information on more than 800 frequently used medicinal plant species from both China and abroad. Each entry of medicinal plant species includes Chinese, Latin and English names, main geographical distribution region, main morphological characteristics, medicinally effective parts, chemical composition, pharmacological effects and the progress in clinical applications. Abundant diagrams are used to supplement the explanations. The book adopted the definition of the medicinal plant species in broader sense, to include not only the traditional medicinal plant species being used for a long time both in China and abroad, but also the new products made from the medicinal plants, natural health plant products, natural plant cosmetics, natural plant pigment, and so on.

The book reflects the results of the authors' in-depth investigations on these medicinal plant species for many years. On the basis of systematic compilation and analysis of the illustrations of the efficacies of these medicinal plants in the voluminous traditional medicinal literatures, the book introduced the latest medical progress in plant biochemistry, pharmacological, toxicological and clinical research. For each medicinal plant species mentioned, the authors also give pertinent comments and suggestions on sustainable exploitation and utilization, as well as safety in clinical applications. All these might contribute greatly to the clarification of the mechanism of the role of the traditional medicine plants, to the modernization of the science of traditional medicinal plants, and to guidance for future clinical applications.

The book is well written with few errors. Abundant illustrations help readers understand the explanations. The book is suitable for professionals who engage in plant science, pharmaceutical research, production, development, testing as well as sales staff or other persons who are interested in these fields.

Li Dezhi[1] and Qin Aili[2]

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Book Review Editor's note: Continuing with our decision to investigate suitable websites and, if appropriate, include their reviews. I have written the following review. If others know of similar suitable sites and are moved to submit a review please contact me at r.john@rogers.com.

MushroomExpert.Com website

By Michael Kuo. 2008. http://www.mushroomexpert.com/index.html.

I recently wanted to identify a mushroom in my yard and, with help, thought it might be a Turkey Tail. On the web I found MushroomExpert.Com, a site developed by an Illinois English teacher and amateur mycologist, Michael Kuo. He is also the author of two conventional books; *Morels* (2005), and 100 *Edible Mushrooms* (2007) [University of Michigan Press]. By following Dr. Kuo's keys and his "Totally True Turkey Tail Test" I confirmed I had a totally true Turkey Tail.

I was very impressed by the individual pages on each species – the field guide section. This section currently covers 700+ mushroom species using identification keys. Each species has a web page with identification information, background material, habitat and some excellent photographs. Some of the photos are by the author, but there are many other contributors. The text is clear and easy to follow and shows a certain sense of humour. I smiled at phrases like "...let me say this as plainly as I can: *You are stupid if you eat this mushroom.*" It certainly gets to the point! There are web links to other mushroom sites, so you can see additional photos and read other versions of the species' characteristics [these were not as attractively displayed nor as well illustrated as Kuo's site].

There are three ways to search. You can step your way through the key system by clicking "Identification keys." For, say, *Boletus luridus* this is a four-step process and leads to Kuo's page [four photos]. For *Boletus flammans* you get moved to RogersMushroom with only one photo.

The second way to get to a species is to select a scientific name from a drop-down box. If you choose *Boletus bicolor* you get to Kuo's page. Oddly, if you go through the keys and decide this is your species there is no link to any further page.

The third method is to go to a search box and type in turkey tail and this will take you out to Google with a link back to MushroomExpert! This will also happen if you enter *Boletus flammans*, and the link will be the page with the link to RogersMushrooms. This all seems a little odd, but it does work. I think this is a reflection on the incomplete status of the site. The author, for example, states "We have not yet completed a key to North American polypores, but we have started the ball rolling with a key to the pale-fleshed, stemmed polypores".

I explored the site further and found it covers Collecting for Study, Making Spore Prints, Descriptions & Journals, Identifying Mushrooms, Determining Odor and Taste, Pronouncing Latin Names, Testing Chemical Reactions, Preserving Specimens, Using a Microscope, Mushroom Taxonomy, Introduction to Mushroom Photography, Digital Photography Tips, Scanning Mushrooms, Eating Wild Mushrooms, Mushroom Toxins, Meixner Test for Amatoxins.

I read a few of these sections and found them informative and remarkably well done. Where required they have excellent illustrations or photographs, including step-by-step sequences. If you intend not to heed the author's warning in paragraph two above, then read the section on toxins. Under Amatoxin he states , in part, "But the remission is a cruel hoax; in the meantime, the victim's liver and kidneys are being destroyed." A very unpleasant thought.

Kuo is currently writing, with Andrew Methven, *100 Cool Mushrooms*, [University of Michigan Press] and *Mushrooms of the Midwest* [University of Illinois Press.]

I have often been frustratingly confused by mushroom field guides. This is the first time I have actually enjoyed the process of resolving identification issues. This site is now in my list of "favourites" – a rare event as I only have 20 or so favourites.

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Between Earth and Sky: Our Intimate Connections to Trees

By Nalini M. Nadkarni. 2008. University of California Press, 2120 Berkeley Way, Berkeley, California 94704-1012. 322 pages. 24.95 USD Cloth.

Nalini Nadkarni, forest ecologist and author of *Between Earth and Sky*, has written a natural and social history of trees, a tribute to the strong and influential global inhabitants she dearly loves. As she writes in the introduction to *Between Earth and Sky*, "I love trees: how they look, how they behave, how they smell and sound, and how I feel when I am around them." The first dedication of her book is to the "maple trees outside the front door, where this book began."

Nine chapters exploring the relationship between humans and trees cover topics as diverse as "what is a tree"; tree goods and services; trees as shelter and protection; trees and health and healing; trees in play and the human imagination; trees and the expression of time; trees as signs and symbols; trees in spirituality and education; and trees and mindfulness. Woven throughout the chapters is scientific fact, personal reflection and narrative, and a variety of visual material.

It is a compelling combination. I found the generous sprinkling of tree quotes, poems and other passages particularly intriguing. Passages from Shakespeare's *Othello*, Homer's *The Odyssey*, and a Woodie Guthrie song. Poems by Wendell Berry, William Blake, John Clare, E. E. Cummings, Jane Hirschfield, Pablo Neruda, Li Po, Rumi, Christina Georgina Rossetti, Percy Bysshe Shelley, and Rabindranath Tagore. Quotes by Hermann Hesse, Federico Garcia Lorca, and Antoine de Saint-Exupéry. One of my favourites is a line from *The Power of Myth* by Joseph Campbell and Bill Moyers: "God is the experience of looking at a tree and saying, 'Ah!'"

Creative writings aside, the book contains no shortage of scientific and other facts. I discovered "arboreal soil" situated on large branches in certain forests, spaces that epiphytes, insects, earthworms, and spiders call home. I learned about "witness trees," which bear permanent marks carved by settlers of forested lands to marks territorial boundaries. I was interested to read that the sacred architecture of Greek temples and Gothic cathedrals is thought to be inspired by sacred groves, and that Hindu and Buddhist temples are in fact associated with living trees.

Anyone who loves trees, who admires their steadfastness, who finds in their presence a certain peace and calm, will love this book. As Nadkarni writes in the introductory chapter, "When I place my own strong brown hand on the trunk of a tree, I feel connected to something that deserves my curiosity, care, and protection." Reading *Between Earth and Sky* makes you want to rush outside and follow her example.

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MISCELLANEOUS

Contributions to the History of Herpetology Volume 2

Edited by Kraig Adler. Society for the Study of Amphibians and Reptiles, Post Office Box 58517 Salt Lake City, Utah 84158-0517 USA. 396 pages. 65.00 USD Cloth.

This is volume 21 in the Society for the Study of Amphibians and Reptiles series *Contributions to Herpetology* begun in 1980. The first history contribution, number 5 in the series, was published in 1989 to commemorate the First World Congress of Herpetology held in Canterbury, England, that year. It contained biographies of 152 "Herpetologists of the Past" compiled by Alder using two criteria for inclusion: (1) significant contribution to herpetology and (2) deceased. Its scope was world-wide and included references for each biography, signatures, and 149 portraits. The book concludes with index to 2500 authors in taxonomic herpetology compiled by John S. Applegarth, and academic lineages of 1300 herpetologists by Robert Altig. It was 202 pages and priced at $20. It is now out of print but it has been put on the web for public access at www.ssarherps.org (click on "Publications"). The new volume extends the coverage of the first and has biographies of 285 additional Past Herpetologists (with signatures and 269 portraits) by Adler. Following sections are an index to 3604 taxonomic authors (again by Applegarth), and academic lineages of 3810 herpetologists (again authored by Altig). The price, in keeping with the times, has more than tripled. Like the first, this is also a commemorative volume, issued for the Society's 50th Anniversary Meeting, St. Louis, 2007.

The new biographies are comprised of both long-deceased herpetologists omitted in the earlier edition and recent ones who have died since the first was written. The accounts are grouped by 26 variable time periods from 1400-1500 to 1970-1990 with placement within each period based on when the person first became prominent in herpetology. Fortunately, there is an index (pages 259-273) covering both volumes that includes page numbers not only for the 437 subjects of individual biographies but also every mention of these and other herpetologists. The bibliographies in volume, 2 begin with Leoniceno (1428-1524) and conclude with Slowinski (1962-2001). The most recent additions are John L. Behler (1943-2006) and Margaret M. Stewart (1927-2006). Canadians, represented by E. B. S. Logier (1893-1979) in the initial volume, have one more entry in the second, Stanley W. Gorham (1917-1984). Stan's career was spent at the National Museum of Canada (now Canadian Museum of Nature) and the New Brunswick Museum and he authored, among other contributions, a checklist of amphibians of the world (1974). Its value is recognized here: "Even when a larger, more comprehensive checklist appeared in 1985, authored by a team of 59 specialists from 20 countries, Gorham's single-authored, simpler list still had the advantage of including synonyms and subspecies and remained a useful reference for many years". [See also 1991 tribute in *Canadian Field-Naturalist* 105: 592-596]. Adler continues to augment his files and there will be many more Canadians represented in a future volume 3 and beyond when the those so active from 1960 to the present are finally eligible for inclusion.

Interest in all corners of the history of biology has come of age and editor Adler is well suited to the task of documenting the herpetological research component. He is Professor of Biology and former Vice Provost for Life Sciences at Cornell University, Ithaca, New York. He has been President of the SSAR and was founding Secretary-General of the World Congress of Herpetology. He has published extensively on behaviour and systematics of amphibians and reptiles in scientific journals and books. He has been, and remains, a driving force in the hyperactive Society for the Study of Amphibians and Reptiles since its foetal days as the Ohio Herpetological Society and the publication of its first journal (1959-1966). He has promoted and edited both the Facsimile Reprints in Herpetology series (41 ranging from pamphlets to books) and the Contributions series as well as being a supporter of varied other publications of the Society: *The Catalogue of Amphibians and Reptiles* (840 accounts to date), *Herpetological Conservation* (2 volumes dealing with Canadian amphibians (1) 1997 and reptiles (2) 2007), *The Herpetological Review* (1967-, at volume 37 in 2006), *Journal of Herpetology* (1968-, at volume 40 in 2006) and *Herpetological Circulars* (1973-, 36 numbers to 2007).

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Science and Conservation of Vernal Pools in Northeastern North America

Edited by Aram J.K. Calhoun and Phillip G. deMaynadier. 2008. CRC Press Boca Raton, 6000 Broken Sound Parkway, NW (Suite 300), Boca Raton, Florida 33487. 363 pages. 97.80 USD Cloth.

Some time ago the public began to notice that urban and private development had started to encroach upon lands which had traditionally been identified as wasteland, swamps and bogs. Habitat was being lost with the destruction of breeding grounds of birds, fish and many mammals to create shoreline, developed areas in subdivisions and agricultural lands where the previous condition of the land had been determined to be "too wet".

As we have spent research time, money and bureaucracy on the identification and preservation of wetlands, biologists have begun to see the further encroachment on lands which are seasonally flooded but do not have the distinction of being wetlands.

Pools of water and the retention of water in a protected setting often occurs in the springtime in many places in forested areas as well as shallow ditches both altered by humans or left by glaciation. With the presence of water, different habitats are created which provide breeding grounds for many invertebrates as well as amphibians, reptiles and birds, become present since the spring is breeding season and the above need habitat which will allow them to go through parts of their life cycles in standing water. Many plants are also associated with pools of water or the moist depressions which are left after the water evaporates. Many of us recognize these plants as common weeds but weeds provide seeds for food, shelter for nesting, and habitat for a variety of fauna to move and live beneath.

Conservation is one stated purpose of the book. Some states have already identified the shallow pools of water present in the spring, and other provinces and states could easily identify similar regions using the criteria outlined here. People who wish to live in country settings often have to alter the natural setting which they have selected in order to build upon it. Developers build according to formulae which sell houses, not rustic settings where the best interests of nature are preserved. Builders choose level versus low-lying ground which leads to bulldozing depressions into lawns and woodlots into open areas. Environmental laws now define the wetlands but the woodland depressions which form vernal pools have neither been identified nor are builders inclined to further limit the buildable space by looking for areas to preserve.

All researchers and professionals in the field who work in areas which are populated by vernal pools can benefit from this rich source. The available literature of flora, fauna, conservation and identification of vernal pools is shown for naturalists and conservationists alike. It has also built upon an earlier work by Elizabeth Colburn, *Vernal Pools: Natural History and Conservation* (Colburn 2004) and borrows heavily from her further research.

This book is a valuable resource in the identification and ecology of seasonal pools which support many amphibians, insects and invertebrates. Reptiles, birds and mammals are also occasional visitors and sometimes breeders. Human building pressures, pesticides, and conservation opportunities are all parts of the study forming the most comprehensive work I have seen on this topic to date. I was only able to read this book slowly because it contains so much research but found myself going back to sections for reference around related topics. It is well researched, carefully prepared and a valuable resource for conservationists.

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Colburn, E.A. 2004. Vernal Pools: Natural History and Conservation. The MacDonald and Woodward Publishing Co., Blackburg, Virginia USA.

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YOUNG NATURALISTS

Amazing Animal Journeys

By Liam O'Donnell. 2008. Tourmaline Editions Inc./DK Publishing Canada. 48 pages. 4.99.CAD Paper.

Snow Dogs! Racers of the North

By Ian Whitelaw. 2008. Tourmaline Editions Inc./DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario, M5V 1M7. 48 pages. 4.99 CAD Paper.

Amazing Animal Journeys and *Snow Dogs! Racers of the North,* both by Canadian writers, are books about animals and travel. *Amazing Animal Journeys*, rated at DK Publishing's Level 3-Reading Alone, is the story of four long-distance wildlife migrations. *Snow Dogs! Racers of the North,* rated at Level 4-Proficient Readers, is about dogs and people travelling together in the north.

Of the two books, *Snow Dogs! Racers of the North* is the most coherent, mainly because it focuses on a single story line: dog sledding. The book is divided into 10 chapters covering topics that include the history of dog sledding, human-dog teamwork, descriptions of high-profile sled-dog races, and profiles of sled-dog racers. The information provided is comprehensive and interesting. The sentence structure is dynamic, flowing, and appropriate to the reading level. And the illustrations, mainly photographs, as well as maps of dog-sled race routes, are plentiful and colourful.

All things considered, *Snow Dogs! Racers of the North* is an interesting, well-written book. My only complaint is with the title, which suggests a book about sled dogs. Yet the content of the book concentrates on sled-dog racing, races, and mushers. While dogs are depicted in most of the photographs, and mentioned on every page, the spotlight is not shone on them very often, and then only briefly.

Two of the book's 48 pages deal with breeds of sled dogs. One paragraph is dedicated to the roles played by dogs positioned at different points along the gangline. One photograph and three sentences portray Balto, the famous lead dog who guided the sled in the last leg of the heroic journey that inspired Alaska's renowned Iditarod Sled Dog Race. Oh yes, the name of another lead dog involved in that journey, Togo, was also mentioned.

The book's title led me to hope for at least one chapter on the various breeds of sled dog developed in differ-

ent parts of the world. Another chapter portraying famous sled dogs, past and present, would have been fascinating, and would have helped round out the book and make it truer to its title. And I would have liked to see more information about the qualities sought for dogs playing different roles on a sled-dog team. The dogs, who work so hard, and who give so much to the sport – without whom the sport would not, in fact, be possible – deserve as much.

The focus of *Amazing Animal Journeys* is definitely on animals. And the stories it tells – about Barren-ground Caribou, Monarch Butterfly, Gray Whale and Snow Goose migrations – are indeed amazing. While the book offers lots of terrific information and colourful illustrations, mainly photographs, it tries, in my opinion, to do too much.

Covering four complex wildlife migrations in 48 pages is itself an amazing feat. To do so successfully would have required either telling fewer migration stories more fully, or telling the same number of stories more simply. The author, unfortunately, tried to take the middle road, and the result is stories that jump around a little too much for smooth reading, and that don't provide enough links between details to make the information flow nicely. That said, the sentence structure is appropriate to the reading level, and the stories are certainly interesting.

Both books, however, left me wanting to know more. And that, perhaps, is not a bad thing.

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NEW TITLES

Prepared by ROY JOHN

† Available for review * Assigned

Currency Codes – CAD Canadian Dollars, USD U.S. Dollars, EUR Euros, AUD Australian Dollars, GBP Great Britain Pound.

ZOOLOGY

The Question of Animal Culture. Edited by Kevin N. Laland and Bennett G. Galef. 2009. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 298 pages. 49.95 USD Cloth

† **Animal Life.** 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 512 pages. 55.00 CAD.

Oxford Dictionary of Biology [Sixth Edition]. By Elizabeth Martin and Robert S. Hine. 2008. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 704 pages. 19.95 USD Paper.

* **Extreme Birds.** By D. Couzens. 2008. Firefly Books Ltd. 66 Leek Crescent, Richmond Hill Ontario L4B 1H1 Canada. 281 pages. 45 CAD Cloth.

Feathered Dinosaurs: The Origin of Birds. By John Long. 2008. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 208 pages. 43.95 USD Cloth.

Witness to Extinction: How We Failed to Save the Yangtze Dolphin. By Samuel Turvey. 2008. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 256 pages. 32.95 USD Cloth.

Egg & Nest. By Rosamond Purcell, Linnea S. Hall, and René Corado, 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 232 pages. 39.95 USD Cloth.

Fish of the Rockies. By Bill Gould, David Propst, Michael G. Sullivan. 2009. Lone Pine Publishing 206, 10426-81 Avenue, Edmonton, Alberta T6E 1X5 Canada. 208 pages. 18.95 CAD Paper.

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Mountain Gorillas: Biology, Conservation, and Coexistence. By Gene Eckhart and Annette Lanjouw. 2008. The Johns Hopkins University Press, 2715 North Charles Street, Baltimore, Maryland 21218-4363 USA. 224 pages. 24.95 USD Cloth.

Organization of Insect Societies: From Genome to Sociocomplexity. Edited by Jürgen Gadau and Jennifer Fewell. 2009. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 518 pages. 79.95 USD Cloth.

Men: Evolutionary and Life History. By Richard G. Bribiescas. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 320 pages. 17.95 USD Paper.

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The Beachcomber's Guide to Seashore Life in the Pacific Northwest. By J. Duane Sept. 2008. Harbour Publishing, PO Box 219, Madeira Park, British Columbia V0N 2H0 Canada. 240 pages. 26.95 USD Paper.

Squirrels of North America. By Tamara Eder. 2009. Lone Pine Publishing 206, 10426-81 Avenue, Edmonton, Alberta T6E 1X5 Canada. 160 pages. 16.95 CAD Paper.

* **Return to Warden's Grove: Science, Desire and the Life of Sparrows.** By Christopher Norment. 2008. Iowa University Press, 2121 State Avenue, Ames, Iowa 50014-8300 USA. 234 pages. 26.00 USD Cloth.

BOTANY

Alaska Trees and Shrubs. Second edition. By Leslie Viereck and Elbert L. Little. 2008. University of Alaska Press, P.O. Box 756240, Fairbanks, Alaska 99775-6240 USA. 370 pages. 24.95 USD.

The Algal Bowl – Overfertilization of the World's Freshwaters and Estuaries. By David W. Schindler and John R. Vallentyne. 2008. University of Alberta Press, Ring House 2, Edmonton, Alberta T6G 2E1 Canada. 348 pages. 34.95 CAD Paper

* **Glistening Carnivores – the sticky-leaved insect-eating plants.** By Stewart McPherson. 2008. Redfern Natural History Productions Limited, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, England, UK. 385 pages. 29.99 GBP Cloth.

Edible and Medicinal Plants of Canada. By Amanda Karst, Linda J. Kershaw, Patrick Owen and Fiona Hammersley Chambers. 2009. Lone Pine Publishing 206, 10426-81 Avenue, Edmonton, Alberta T6E 1X5 Canada. 448 pages. 29.95 CAD Paper.

Major Evolutionary Transitions in Flowering Plant Reproduction. By Spencer C. H. Barrett. 2008. University of Chicago Press, 1427 E. 60th Street, Chicago, Illinois 60637 USA. 216 pages. 30.00 USD Paper.

MISCELLANEOUS

Outside in the Interior: An Adventure Guide for Central Alaska. By Kyle Joly. 2007. University of Alaska Press, P.O. Box 756240, Fairbanks, Alaska 99775-6240 USA. 160 pages. 19.95 USD Paper.

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Crosscurrents North – Alaskans on the Environment. Edited by Marybeth Holleman and Anne Coray. 2008. University of Alaska Press, P.O. Box 756240, Fairbanks, Alaska 99775-6240 USA. 320 pages. 26.95 USD.

Audubon: Early Drawings. By John James Audubon. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 288 pages. 125 USD cloth.

Sustaining Life: How Human Health Depends on Biodiversity. By Eric Chivian and Aaron Bernstein. 2008. Oxford University Press, 198 Madison Avenue, New York, New York 10016 USA. 528 pages. 39.50 USD Cloth.

Wild Costa Rica: The Wildlife and Landscapes of Costa Rica. By Adrian Hepworth. 2008. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 USA. 176 pages. 29.95 USD Cloth.

CO_2 Rising: The World's Greatest Environmental Challenge. By Tyler Volk. 2008. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 USA. 264 pages. 22.95 USD or 14.95 GBP Cloth.

The Shadows of Consumption: Consequences for the Global Environment. By Peter Dauvergne. 2008. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 USA. 328 pages. 24.95 USD or 16.95 GBP Cloth.

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Plains Apache Ethnobotany. By Julia A. Jordan. 2008. University of Oklahoma Press, 1005 Asp Avenue, Norman, Oklahoma 73019 – 0445 USA. 240 pages. 34.95 USD.

Evolution: The First Four Billion Years. Edited by Michael Ruse and Joseph Travis. 2009. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 992 pages. 39.95 USD Cloth.

The Better to Eat You With: Fear in the Animal World. By Joel Berger. 2008. University of Chicago Press, 1427 E. 60th Street, Chicago, Illinois 60637 USA. 360 pages. 29.00 USD Cloth.

Global Catastrophes and Trends. By Vaclav Smil. 2008. The MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142 USA. 320 pages. 29.95 USD or 19.95 GBP Cloth.

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The Accidental Mind: How Brain Evolution Has Given Us Love, Memory, Dreams, and God. By David J. Linden. 2008. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138 USA. 288 pages. 17.95 USD Paper.

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Canadian Rockies Access Guide – Revised and Updated. By John Dodd, Gail Helgason and Jennifer Groundwater. 2009. Lone Pine Publishing 206, 10426-81 Avenue, Edmonton, Alberta T6E 1X5 Canada. 400 pages. 26.95 CAD Paper.

Chasing Science at Sea: Racing Hurricanes, Stalking Sharks, and Living Undersea with Ocean Experts. By Ellen Prager. University of Chicago Press, 1427 E. 60th Street, Chicago, Illinois 60637 USA. 178 pages. 22.50 USD Cloth.

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YOUNG NATURALISTS

Animals: A Visual Encyclopedia. 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 304 pages. 32.99 CAD.

Animal Families. 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 64 pages. 13.99 CAD.

* **DK Readers Level 3: Amazing Animal Journeys.** By Liam O'Donnell. 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 48 pages. 4.99 CAD Cloth.

* **Earth Matters.** 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 256 pages. 27.99 CAD Cloth.

Sharks and Other Creatures of the Deep. 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 144 pages. 21.99 CAD.

* **DK Readers Level 4: Snow Dogs.** By Ian Whitelaw. 2008. Tourmaline Editions Inc., DK Publishing Canada, 662 King Street West, Suite 304, Toronto, Ontario M5V 1M7 Canada. 48 pages. 4.99 CAD Cloth.

News and Comment

Marine Turtle Newsletter (118)

October 2007. 32 pages: EDITORIALS: Conservation Conflicts, Conflicts of Interest, and Conflict Resolution: What Hopes for Marine Turtle Conservation? (L. M. Campbell) — ARTICLES: From Hendrickson (1958) to Munroe & Limpus (1979) and Beyond: An evaluation of the Turtle Barnacle *Tubicinella cheloniae* (A. Ross and M. G. Frick) — Nest Relocation as a Conservation Strategy: Looking from a Different Perspective (O. Turkkozan and C. Yilmaz) — Linking Micronesia and Southeast Asia: Palau Sea Turtle Satellite Tracking and Flipper Tag Returns (S. Klain, J. Eberdong, A. Kitalong, Y. Yalap, E. Matthews, A. Eledui, M. Morris, W. Andrew, D. Albis and P. Kemesong) — Morphometrics of the Green Turtle at the Atol das Rocas Marine Biological Reserve, Brazil (A. Grossman, P. Mendonca, M. Rodriques da Costa, and C. Bellini) — NOTES: Epibionts of Olive Ridley Turtles Nesting at Playa Ceuta, Sinaloa, Mexico (L. Angulo-Lozano, P. E. Nava-Duran and M. G. Frick) — Self-Grooming by Loggerhead Turtles in Georgia, USA (M. G. Frick and G. McFall) — IUCN-MTSG QUARTERLY REPORT — ANNOUNCEMENTS — NEWS & LEGAL BRIEFS — RECENT PUBLICATIONS.

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The Vermont Reptile and Amphibian Atlas Project Publishes the First Vermont Amphibian Posters

The Vermont Reptile and Amphibian Atlas Project has produced two informational posters on the amphibians of Vermont. Amphibians Part 1 contains the frogs of Vermont and Amphibians Part 2 contains the salamanders of Vermont. Photographs of all Vermont amphibians are included on the posters along with the latest available (2005) distribution maps, identification information, and the basic natural history of each species. These posters reflect the most reliable and current information available on Vermont amphibians. Each color poster is approximately 23" by 16" and is printed on durable, glossy, heavyweight paper with non-fading inks. Posters cost $9.43 each ($10 with VT sales tax) with a $3 shipping charge. In 2006, two Vermont reptile posters were printed and all four posters can be seen at the Atlas website http://community.middlebury.edu/~herpatlas/index.html. All proceeds from the sale of the posters will help fund the Vermont Reptile and Amphibian Atlas project.

The Vermont Reptile and Amphibian Atlas Project is an effort begun in 1994 by the Vermont Reptile and Amphibian Scientific Advisory Group to the Endangered Species committee. The atlas project initially began as an effort to gather data for use by this volunteer advisory group in order to make informed recommendations regarding the appropriate status and conservation of reptiles and amphibians in Vermont. Since then, the goals have widened to incorporate public education, encourage citizen involvement, and promote conservation. The Atlas Project is coordinated by Jim Andrews, a research herpetologist at Middlebury College. The ultimate goal of the Atlas is to gather and disseminate data on reptiles and amphibians in Vermont in a way that involves and informs Vermont individuals and organization so that they will become more informed and effective stewards of wildlife habitat. Since the Atlas began in 1994, over 3,000 individuals, fifteen private organizations, and many government employees and agencies have provided over 60 000 records of local reptiles and amphibians. With the help of these volunteers and a few part-time staff members, the atlas continues to collect information and broaden the knowledge base regarding the natural history, distribution, and effective conservation of Vermont's reptiles and amphibians.

Any resident or visitor can contribute valuable distribution information simply by reporting what they saw, when they saw it, and where it was. Reports can be forwarded by mail, phone, or better yet, through the use of online reporting system at the website http://community.middlebury.edu/~herpatlas/index.html. Photographs are particularly helpful but not necessary. With a good description, sketch, or photograph, they can figure out what species you have observed and enter it into their database. The data help them generate accurate maps of the in-state distribution of Vermont's native herptofauna.

Maps at their website show clearly the towns and species most in need of additional survey work. Some of the towns most in need of additional reports include Lunenburg, Lyndon, Andover, Baltimore, Burke, Danville, Granby, Irasburg, Rutland, Cabot, Derby, Elmore, Warner's Grant, Avery's Gore, and Pittsfield. Cities most in need of additional surveys include St. Albans, Barre, Newport, and Vergennes. Species most in need of additional reports include all reptiles but particularly snakes other than Gartersnake and all turtles. However, gaps exist in the distribution maps for even some common species and in some towns that have been surveyed more thoroughly.

Additional information on the posters, how to contribute to the survey effort, and resources on identification and natural history of these species groups can be found at http://community.middlebury.edu/~herpatlas.

For more information please contact James Andrews, Vermont Reptile and Amphibian Atlas, Sunderland 114, Middlebury College, Middlebury, Vermont 05753 jandrews@middlebury.edu.

The Ottawa Field-Naturalists' Club Awards for 2006

Irwin M. Brodo, Christine Hanrahan, Diane Lepage, and Eleanor Zurbrigg

On April 28, 2007, members and friends of the Ottawa Field-Naturalists' Club gathered at the Club's Annual Soirée at St. Basil's Church in Ottawa, and once again, awards were given to members, and one non-member, who distinguished themselves by accomplishments in the field of natural history and conservation, or by extraordinary activity within the Club. Careful observation of plants and animals, political savvy, selfless service, and teaching skills are all in evidence among this year's winners. The following citations for those who received an award were read to the members and guests assembled for the event.

Annie Bélaire – Member of the Year

The OFNC's Member of the Year award recognizes the club member judged to have contributed the most to the club during the previous year. Annie Bélaire is this year's Member of the Year for her dedicated, creative and innovative involvement with the Macoun Club, as well as her work as a volunteer at the Fletcher Wildlife Garden.

Annie started working with the Macoun Field Club four years ago, in the fall of 2003. Annie attends every meeting and field trip as a knowledgeable leader, always ready to answer children's questions and enrich their experience with her special knowledge. For example, when the group found the fresh remains of a big coyote-killed deer in Stony Swamp, she eagerly seized the skull and pointed out to all who were gathered around, "You can tell this was still a young deer, because the teeth are still sharp and the dentine and enamel are of equal thickness!" Understanding that part of Stony Swamp is the Club's Study Area, she undertook a resurvey of Eastern Hemlock trees and found that their population has declined severely over the past 15 years, owing to a special fondness of porcupines and deer for their foliage. She then shared her findings with the children at a Macoun Club meeting, and wrote up her report for the Club's *Little Bear* magazine.

In the face of declining membership in the Macoun Field Club in recent years, it became clear that one of the major problems is "getting the word out," i.e., publicity. To help the Macoun Club reach families with young children, Annie designed a vibrantly coloured new brochure and a poster, which have become significant parts of its publicity efforts.

Aside from her energetic efforts with the Macoun Club, Annie participates as a willing volunteer at the Fletcher Wildlife Garden as part of the Friday morning crew working in the Backyard Garden and Butterfly Garden, and also serving on the FWG committee. In addition, Annie has done translations for our brochures and other bilingual Club documents, and she has put a lot of time into organizing and data-basing the library.

Annie Bélaire is clearly well qualified to be our Member of the Year for 2006.

Christina Lewis – George McGee Service Award

The OFNC George McGee Service Award is given in recognition of a member who has contributed significantly to the smooth running of the Club over several years.

Since joining the OFNC in 1995, Chris Lewis has been an exceptionally busy and productive member of the club. A long-time member of the Birds Committee, Chris has served as recording secretary since 2001, a position she continues to fill. Many club members will recognize Chris as one of the stalwarts of the Seedathon team who not only organizes, but participates in this important event to raise money for the purchase of seeds for all the OFNC bird feeders in the region.

Chris is the recorder and reporter for the OFNC's Bird Status line, a position she has held since 2001. She is responsible for making sure the data are logged, recorded, and ultimately submitted to ONTBIRDS, the provincial listserv for bird observations. This is no small task and is vitally important if we are to have reliable data on bird occurrences in this region.

In 2003, Chris joined the OFNC's Bird Records Subcommittee, which is responsible for reviewing all rare bird reports from the region. A very keen and knowledgeable birder, Chris has also written numerous rare bird reports since 1995. In addition, she contributes significantly to the Bird Records Subcommittee database.

Chris is also responsible for many of the regular quarterly bird summaries in *Trail & Landscape*. She has also authored or co-authored many other articles for *T&L*, most recently an excellent report on the first confirmed nesting of the Double-crested Cormorant in Ottawa. Chris authored the significant species summaries for the Ottawa area for the *Birder's Journal* (2001-2004), and for the American Birding Association's *North American Birds* (2001 to the present).

With Bob Bracken, she has co-authored several articles promoting Ottawa area bird-watching for "OFO News", the newsletter of the Ontario Field Ornithologists.

When the Ontario Field Ornithologists held their annual convention in Ottawa in September 2006, Chris very capably assisted not only with promotion of field trips for this event, but helped to lead several very successful trips.

While many people may connect Chris with birds, there are many more who know her as an expert on odonates – dragonflies and damselflies, and on Lepidoptera. Over the last decade she has led or co-led numerous walks for the OFNC on birds, butterflies, dragonflies (the Morris Island dragon walks are very popular), fish and general natural history.

Her interest in, and knowledge of, odonates has led her to publish some important articles on dragonflies and damselflies of the Ottawa area, and submit an astonishing 2,000+ records of odonates for the Ottawa area, together with Bob Bracken, to the Ontario Odonata Summaries. She and Bob received the 2001 Anne Hanes Natural History award for this work.

These are remarkable contributions, both in terms of service to the club and to the furthering of our knowledge of natural history in this area. For all of these reasons, the OFNC is pleased to give the 2006 Service Award to Christina Lewis.

Madeline Kallio – Conservation Award (Non-Member)

The OFNC Conservation Award – Non-Member is given in recognition of an outstanding contribution by a non-member in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

For nine years, Madeline Kallio has been the driving force behind the National Capital Region Wildlife Festival. Through its Wildlife Awareness event, library programs, public forums, guided nature walks and more, the festival has, for many years, introduced the general public to natural history and the concept of conservation.

While the festival appears to run effortlessly, in fact, a tremendous amount of organization and year-round planning is required. Madeline Kallio chairs the festival committee which meets approximately 11 times a year, produces the minutes, and attends to the thousand and one details that arise. She is the liaison with the Billings Bridge Shopping Centre (where the wildlife awareness event takes place), drawing up detailed floor plans, and ensuring that everything needed to make this particular event run smoothly is taken care of. She is also the link with all the exhibitors, contacting them each year, determining their requirements, making sure they have the right location for their exhibit, etc. She staffs the Wildlife Festival booth for the entire three days and is always available should other exhibitors need assistance. Coordinating an event of this magnitude and ensuring that it runs smoothly requires skill, good organizational abilities and huge time commitments.

Madeline also writes all the grant proposals and constantly seeks new ways to fund this event. In addition, she writes, produces and prints the festival's events brochure. A few years ago, she came up with the brilliant idea of developing a map of greenspaces in eastern Ontario where people can explore nature. Called "On the Trail of Mother Nature" this large, full-colour map, prepared, researched, and primarily designed by Madeline, has been a huge success with several updates and thousands of copies distributed.

Madeline is full of ideas for making the festival ever more interesting. One example is the library program series, which is so popular that presenters from previous years contact Madeline to make sure they are included in the current line-up, while libraries begin asking for information well in advance of the festival itself. She encouraged the idea of a public forum (now in its fifth year), has been instrumental in organizing the festival's Environmental Awards ceremony, and probably has a hundred other ideas just waiting to burst forth! Endlessly resourceful, energetic, and tireless, Madeline is always willing to step in and pick up where needed. On top of all this, she is always a calming, cheerful presence, seemingly unflappable, and without a doubt is the glue that holds the festival together!

Long before she was the festival's Coordinator, Madeline was a member of the festival committee, joining in 1990. When a coordinator was needed, Madeline stepped in and has not looked back.

You might think that the festival was enough to keep Madeline occupied full-time. This would be true for most people, but Madeline is involved in a number of other activities, including volunteering for the Kanata Canada Day program. She is also an accomplished writer who has written and published many articles and brochures. Chances are, you have seen her writing. If you have picked up brochures on Lanark County Maple Byway Tours, or browsed the 'Coffee Companion' newsletter in a Kanata coffee house, read magazines such as Fifty-Five Plus or Due West, you've seen her work.

Back in 1985, Madeline set up Ottawa Valley Field Trips, to introduce young and old to the joys of the natural world. She developed hands-on environmental programs for schools, organized workshops on natural history themes for the school boards, and worked extensively on nature interpretation programs with the National Capital Commission, Scouts Canada, Girl Guides, the Home School Association and other learning and public groups. The company also developed "backroads tours", which explored interesting villages and natural areas on the backroads of Eastern Ontario, as well as longer trips in Ontario, Quebec and the U.S.

The OFNC is proud to recognize Madeline Kallio for her outstanding efforts on behalf of nature and conservation in the Ottawa region, and in particular for her work with the National Capital Region Wildlife Festival.

Frank Pope – Conservation Award (Member)

The Conservation Award for Members is presented in recognition of an outstanding contribution by a member of the OFNC in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District. Frank Pope is chosen as the recipient for the 2006 award in recognition his skillful leadership of the Alfred Bog Committee for over 20 years, which in 2006 achieved its goal of protection for the Alfred Bog for generations to come. Alfred Bog, lying 75 kilometres east of Ottawa, is one of the great conservation success stories of the past two decades. It took long years of hard work by local groups and all levels of government to finally save this vulnerable wetland from peat extraction, logging and drainage.

Frank Pope's involvement in the Alfred Bog conservation effort began in earnest in the early 1980s. A large part of the bog had been re-zoned to Agriculture, and an appeal to the Ontario Municipal Board seeking to keep the zoning as Conservation had failed. Not willing to accept defeat, Frank Pope, with Charles Sauriol of the OFNC, created the Alfred Bog Committee in 1985 to bring together interested folks and strengthen the bog protection effort. (At the time, Frank could not have known that it would take over 20 years to achieve success!) Frank chaired the Alfred Bog Committee in its ongoing save-the-bog campaign for the ensuing 20+ years, a long, drawn-out struggle that, against the odds, achieved its goal.

In this exhausting battle, Frank's commitment never wavered in the face of setbacks. His efforts spanned a range of activities — making credible presentations at Ontario Municipal Board hearings, tribunals, advocating legislative change at the provincial level (for example, to enable municipalities to control peat extraction activities), commenting on official plans and by-laws, working with major NGOs (NCC) in land acquisition efforts, fund-raising, and negotiating with diverse groups to name but a few.

Under Frank's leadership, the Alfred Bog Committee watched for acquisition opportunities within the bog, and initiated such activities as the preparation of a management plan, a major report on the plants, animals and hydrology of the bog, contacts with other land holders in the bog, the preparation of educational brochures and articles and field trips into the bog. Funding was obtained and a 1000 ft. boardwalk was constructed in the bog, because the impressive natural features of the bog made it a popular destination for naturalists and outdoor lovers, whereas walking in the bog is destructive to bog flora and hazardous to walkers.

In the years leading up to 2004, the combined conservation work of non-governmental groups and the several levels of government intensified. The Nature Conservancy of Canada purchased a total of 2800 hectares of the bog, and Ontario Parks now holds title to this property, to be managed as a provincial nature reserve. Peat harvesting within the bog was banned when the Prescott-Russell County Council passed the Alfred Bog Protection By-Law. In addition, peat-mining operations that border the bog and still pose a threat to its integrity are now required to operate according to rules designed to minimize this threat. All appeals of the county official plan pertaining to the Bog are withdrawn and the years-long mediation of the Ontario Municipal Board terminated. The Bog now has an official boundary and wetland designation. Quite a success story!

With this conservation award, the OFNC is recognizing Frank Pope's unflagging commitment, leadership and final success in the effort to gain environmental protection for Alfred Bog. Congratulations, Frank!

Linda Jeays – Anne Hanes Natural History Award

This award is given in recognition of a member who, through independent study or investigation, has made a worthwhile contribution to our knowledge, understanding and appreciation of the natural history of the Ottawa Valley.

Linda Jeays, an enthusiastic birder and longtime member of OFNC, began to study butterflies as a Millennium project. Her first identification was a Black Swallowtail flushed while watching waterfowl at Richmond lagoons. She jotted down a description, later referred to a field guide, and suddenly had a new natural history interest.

Linda is a former English teacher with an inclination towards note-taking. In her first summer studying Lepidoptera she began to make detailed documentation on every butterfly she encountered except where numbers made this impractical. She also keeps data on topics such as flight season, habitat, nectaring plants, road-kill and garden species.

At the end of the 2001 season, Linda learned that her sightings of Eastern Tailed Blue and Common Buckeye were very rare in the Ottawa area. Encouraged by Ross Layberry to write up her observations for *Trail & Landscape* and to check the locations again the following year, her detailed notes soon became valuable. In 2002, Linda again saw Buckeye briefly, but her real work began when she netted Eastern Tailed Blue within 10 feet of a previous year's site. In the very few records available, no one else had reported the butterfly in a repeat location.

What if Eastern Tailed Blue had overwintered? Linda began spending many hours each week netting, measuring and individually marking the Blues. Each year she recorded her findings in T&L, accumulating proof of overwintering. She has now established the presence of this species at one site near Richmond for six consecutive years. The culmination of Linda's work came in the summer of 2006 when she spent over 250 hours

in the field documenting the population explosion and widespread dispersal of Eastern Tailed Blue. She herself tallied 30 locations and 160 individuals. Another 25 sites and 170 Blues were reported by independent contributors to the Annual Eastern Tailed Blue Roundup that Linda conducts.

Linda Jeays has written feature articles, essays, humour, book reviews and autobiographical material for newspapers such as the *Ottawa Citizen* and the *National Post*. She has many magazine credits and has worked on assignment for the Canada Safety Council. Linda wrote her first short item for *T&L* in 1975. In 1977 she called then-editor Anne Hanes about submitting a piece of free verse. Anne said that unfortunately *T&L* did not use poetry, but she would still like to read the poem. "Metamorphosis" was printed in January 1978, the first of Linda's 35 poems in the club magazine

Anne Hanes would surely have been pleased that her early encouragement of the creative expression of Linda's nature observations has developed into meticulous factual documentation of Eastern Tailed Blue and a worthwhile contribution to the knowledge and understanding of this butterfly in the Ottawa Valley.

For her outstanding contribution to our further knowledge of the Eastern Tailed Blue in the Ottawa Region, we are very pleased to present Linda Jeays with the Anne Hanes Natural History Award for 2006.

Isabelle Nichol – Mary Stuart Education Award

The Mary Stuart Education Award was established to recognize members, non-members or organizations, for their outstanding achievements in the field of natural history education in the Ottawa Region. The OFNC is pleased to give the award for 2006 to Isabelle Nicol.

Isabelle has a great affinity for teaching natural history. She is both knowledgeable and enthusiastic and conveys this interest to the many lucky people who have been in her classroom or participated in her many field trips. Isabelle was a former employee of the NCC but, before she left that job, she was actively working on this, her second career that she has pursued so successfully for over 15 years.

Isabelle is a freelance teacher of natural history who is invited back year after year in several local schools because of her natural ability to teach and because of her careful planning of various natural history modules that complement the subjects covered in the grade school curriculum. These include modules on habitats, plants, hibernation in winter, migration, spring ephemerals and active winter wildlife. She works closely with the teachers to tailor her teaching to fit the interests and abilities of the students at hand.

Recently Isabelle has branched out and now also teaches natural history to various senior citizen groups and garden clubs. Over these many years Isabelle has also been a much sought after field trip leader for our Club, where participants have come to appreciate her quiet style and originality. We have a first rate natural history teacher in our midst and it is time that she be appropriately honoured.

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